



PALESTINE JOURNAL OF BOTANY

Jerusalem Series

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JERUSALEM

PALESTINE JOURNAL OF BOTANY

appears in two series

THE JERUSALEM SERIES (J)

edited by the staff of the Department of Botany of the Hebrew University, Jerusalem. Four issues of JERUSALEM SERIES appear during the year, each number bearing the date of publication. The size of the annual volume of JERUSALEM SERIES varies from 300 to 400 pages.

THE REHOVOT SERIES (R)

edited by H. R. OPPENHEIMER and I. REICHERT, Agricultural Research Station, Rehovot, Palestine. Two issues of REHOVOT SERIES appear during the year, each number bearing the date of publication. The size of the annual volume of REHOVOT SERIES varies from 200 to 250 pages.

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Correspondence concerning editorial matters should be addressed for the JERUSALEM SERIES to D. V. ZAITSCHEK, P.O.B. 620, JERUSALEM, PALESTINE, for the REHOVOT SERIES to THE EDITORS, PALESTINE JOURNAL OF BOTANY, P.O.B. 15, REHOVOT, PALESTINE.

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Subscriptions are payable in advance by crossed cheque or postal order and should be forwarded to the ADMINISTRATION of the PALESTINE JOURNAL OF BOTANY, P.O.B. 620, JERUSALEM, PALESTINE. The subscription price is

25 s. per annum, post free, for both series

18 s. per annum, post free, for JERUSALEM SERIES separate

12 s. per annum, post free, for REHOVOT SERIES separate.

(single number 6 s., double number 12 s.).

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Printed in Palestine
Azriel Press Jerusalem.

PALESTINE
JOURNAL OF BOTANY

Vol. II. No. 1

Jerusalem Series

June, 1940

ON GERMINATION INHIBITORS

I. INTRODUCTION

By M. EVENARI

Under the influence of research on growth-stimulating substances, the rapid progress of developmental physiology has tended to obscure the fact that ontogeny is not a continuous process of development, but is interspersed with periods in which development is completely or partially inhibited. It is during such periods that development inhibiting factors are predominant.

One of the most important phases of development-inhibition is that connected with germination inhibition, which has its seat in the seed or in the fruit and is not caused by outside factors, such as chemicals for example. It is especially during the last few years that our attention has been drawn again to these facts.

As early as the thirteenth century ALBERTUS MAGNUS (8) made the observation that pear and apple seeds which are inside the fruit germinate worse than when free of their fruit. Since then research in this field has been abandoned to be reopened by OPPENHEIMER (14, 15). This author has been recently followed by others who have examined his results and have studied the same problem from other viewpoints. As an introduction to several papers on germination inhibitors we wish to give a short summary of results obtained so far as well as of problems which remain to be solved.

(1) The inhibition of germination is the result of germination-inhibiting substances which diffuse from seed or fruit and may accumulate in the germination bed (1, 3, 4, 6, 7, 10, 11, 13, 16, 17, 18).

(2) These germination inhibitors are water-soluble and may be extracted with water from seed or fruit (4, 6, 7, 10, 11, 13, 14, 15, 16).

(3) The germination inhibitors are ether-soluble (6, 10). In contrast with this, OPPENHEIMER (14, 15) states that they are precipitated by ether.

(4) In some cases the germination inhibitors appear to be volatile (1 and also following papers by VAHL and by KONIS).

(5) The germination inhibitors may be adsorbed to several adsorbentia, above all to carbo animalis (1, and also following paper by VAHL). Soil (1) is such an adsorbent. This fact has been pointed out by OPPENHEIMER for the first time when he spoke of the "stimulating action of soil on germination" (15).

(6) The germination inhibitors are not specific. FROESCHEL (4) for example has been able to prove that the germination inhibitor of *Trifolium pratense* and *Beta vulgaris* acted on the seeds of 28 other species as well.

(7) The thermostability of the germination inhibitors is as yet controversial. OPPENHEIMER (14, 15), MOSHEOV (13) and LEHMANN (10) state that the inhibiting substance is thermolabile, while KOECKEMANN (6) and REINHARD (17) consider it thermostable. It is not clear whether the difference results from the study of different plants or is caused by different experimental conditions.

(8) The inhibiting effect is a function of the concentration of inhibiting substance (3, 14, 15, and also following paper of KONIS).

(9) The inhibiting effect is coupled with a stimulating effect:

(a) The effect varies with the concentration. If water extracts which contain the germination inhibitor are much diluted, stimulation, instead of inhibition, is observed (10 and also following paper by KONIS).

(b) The effect varies with time. As time passes the inhibiting effect gradually changes into stimulation (13, 14, 15, 18). It is not clear whether this is produced by two antagonistic substances, or whether, as RUGE (18) states, the same substance first inhibits, and then stimulates, chemical change following.

(10) In the case of *Phacelia tanacetifolia*, which germinates only in the dark, it has been found that the inhibitor is much

more effective in the presence than in the absence of light (11, 16). MOSHEOV (13), to whom the afore-cited works were not known, obtained the same results for the inhibiting substance of wheat, although wheat does not require darkness for germination.

(11) The chemical structure of the inhibiting substance is still unknown, KOECKEMANN, however, (6, 7) has designated it Blastokolin. COPISAREV's (2) view that it may be maleic acid has not proved to be true. Whether hydrocyanic acid, which originates from the naturally-occurring amygdalin (9), is identical with the inhibiting substance remains to be proved.

(12) Concerning location of the germination-inhibiting substances the following observations have been made.

(A) The germination inhibitor is localised in the fruit.

(a) The fruit-pulp contains the germination inhibitor (KOECKEMANN (6, 7) in pears and apples, VAHL in following paper on *Poterium spinosum*).

(b) In fleshy fruits the germination inhibitor is contained in the juice (OPPENHEIMER (14, 15), KOECKEMANN (6, 7), REINHARD (17) on tomatoes).

(c) The germination inhibitor is found in the fruit coat (MOSHEOV (13) on *Triticum*, RUGE (18) on *Helianthus*, LEHMANN (10) on *Fagopyrum*, OPPENHEIMER (14, 15) on *Nicotiana rustica*, *Capsicum annuum*, *Papaver somniferum*, REINHARD (17) on the tomato, SROELOV (in a following paper) on *Sinapis*).

(B) The inhibitor is localised in the seed (BORRISS (1) on *Vaccaria*, RUGE (18) on *Helianthus*, MAGNUS and PETERS (11, 16) on *Phacelia*). RUGE (18) even succeeded in finding differences in activity within the embryo. He showed that all parts of the embryo prepared from the non-soaked seeds act first as germination inhibitors. 6 hours after soaking, plumule, radicle and the cotyledons stimulate. If the same parts are isolated from soaked seeds the plumule stimulates, the radicle inhibits at first, then it stimulates, and the cotyledons inhibit.

(13) After all FROESCHEL (3) may be right in considering the presence of germination inhibitors in seeds (and probably in fruits too) a general fact.

When, some years ago, our Department began to investigate germination-inhibiting substances we set before us the following tasks:

(a) To study the physiological effect of germination-inhibitors.

(b) To investigate whether germination-inhibitors of the described kind are of general occurrence in seeds and fruits and what their ecological importance may be.

(c) To elucidate the chemical composition of the germination-inhibitors.

A first contribution to this study was the work of our pupil MOSHEOV (13) whose untimely death put an end to his endeavours. The following 3 papers are other contributions.

In the next issue of the Palestine Journal of Botany a fifth article, on the chemical isolation of the germination inhibitors, will be published.

REFERENCES

- (1) BORRISS, H. (1936). Ueber das Wesen der keimungsfoerdernden Wirkung der Erde. *Ber. deutsch. bot. Ges.* 54: 472-486.
- (2) COPISAREV, M. (1935). A new method of fruit and vegetable preservation. The metabolism of apples. *Industr. Chem.* 54:
- (3) FROESCHEL, P. (1939a). Onderzoekingen over de physiologie van de kieming. I. Remstoffen. *Naturwet. Tijdschr.* 21: 93.
- (4) FROESCHEL, P. (1939b). Remstoffen van zaden en hun invloed op het kiemingspercentage. *Mededeel. Landbouwhoog. Opzoekingsst. Stadt Gent*, 7: 238.
- (5) FUKAKI, S. (1930). Ueber die Frage der Beeinflussung des eigenen Fruchtsaftes auf die Samenkeimung. *Bull. Sci. Fac. Terkult. Kjusu Imp. Univ.* 4:
- (6) KOECKEMANN, A. (1934). Ueber eine keimungshemmende Substanz in fleischigen Fruechten. *Ber. deutsch. bot. Ges.* 52: 523-526.
- (7) KOECKEMANN, A. (1936a). Zur Frage der keimungshemmenden Substanzen in fleischigen Fruechten. *Beih. Bot. Ctrbl. Abt. A*, 55: 196.
- (8) KOECKEMANN, A. (1936b). Albert der Grosse, der Entdecker der keimungshemmenden Wirkung des Fleisches saftiger Fruechte. *Ztschr. ges. Naturw.*
- (9) LAIBACH, F. und KEIL, J. (1937). Ueber die keimungshemmende Wirkung der freien Blausaeure. *Ber. deutsch. bot. Ges.* 55: 579-583.
- (10) LEHMANN, W. (1938). Zur Keimungsphysiologie des Buchweizens. *Landw. Jahrb.* 84: 741.
- (11) MAGNUS, W. (1920). Hemmungsstoffe und falsche Keimung. *Ber. deutsch. bot. Ges.* 38: (19)-(26).

- (12) MOLISCH, H. (1937). *Der Einfluss einer Pflanze auf die andere. Allelopathie.* Jena.
- (13) MOSHEOV, G. (1938). The influence of the water extract of wheat seeds upon their germination and growth. *Palest. Journ. Bot. J Series*, 1 : 86-92.
- (14) OPPENHEIMER, H. (1922a). Keimungshemmende Substanzen in der Frucht von *Solanum Lycopersicum* und in anderen Pflanzen. *Sitzungsber. Wien. Akad. Wiss. Abt. I*, 131 : 59-65.
- (15) OPPENHEIMER, H. (1922b). Das Unterbleiben der Keimung in den Behältern der Mutterpflanze. *Sitzungsber. Wien. Akad. Wiss. Abt. I*, 131 : 279-312.
- (16) PETERS, Th. (1924). Die Wirkung des Lichtes bei der Keimung der Samen von *Phacelia tanacetifolia*. *Ber. dtsh. bot. Ges.* 42 : 381-387.
- (17) REINHARD, A. W. (1933). Zur Frage der Samenkeimung bei *Solanum Lycopersicum*. *Planta*, 20 : 792-794.
- (18) RUGE, U. (1939). Zur Physiologie der genuinen keimungshemmenden und beschleunigenden Stoffe von *Helianthus annuus*. *Ztschr. Bot.* 33 : 529.

ON GERMINATION INHIBITORS

II. ON THE ACTION OF GERMINATION INHIBITING SUBSTANCES IN THE TOMATO FRUIT

By E. KONIS

(With Plate I and 7 figures in the text)

INTRODUCTORY

As a result of recent research, the existence of substances which stimulate and inhibit germination has generally been postulated. With respect to germination inhibitors, however, few systematic investigations have been carried out, and little is known of their nature and action. Their very existence even, has not yet been definitely proved. However, the inhibitory effect itself lies beyond all doubt.

The present work on germination-inhibiting substance of the tomato has been carried out with the following objects in view:

(1) To prove the existence of germination inhibitors in fleshy fruits.

(2) To discover their properties.

(3) To study the mechanism of their action.

For a review of the literature on germination inhibition the reader is referred to EVENARI (1940).

MATERIALS AND TECHNIQUE

As a result of preliminary experiments, tomatoes of the Stanford's Immun variety were selected for our experiments it having been shown that of all varieties available on the Palestine market, this possesses the most strongly inhibiting juice. For each series of experiments we selected tomatoes of approximately equal ripeness, as it was found that the inhibiting effect increases as ripening progresses.

Juice was prepared by pressing the tomatoes and filtering. A clear liquid was obtained. Juice was also dialysed in cellophane tubes placed in cylinders through which a steady stream of water was passed.

The seeds selected for germination were generally Nursi wheat grains. In some cases we employed six-rowed barley M.38, oat and maize grains.

Each germination experiment was conducted in two or four Petri dishes, on the bases of which was fitted a single layer of filter-paper. Twenty-five seeds were then placed on the filter-paper and 10 cc. of juice were introduced. On the following day the excess liquid was poured out, only the filter-paper remaining moist. In most cases parallel experiments were conducted on dialysed tomato juice. Control tests were also performed, employing tap-water.

The Petri dishes were stood in the laboratory near a window facing north, or in a thermostat at 26° C. The progress of germination was studied from observations made on the rate of germination, the final percentage of germinated seeds, and the development of germinated seedling. At first, development was followed by measuring the length of the radicle and coleoptile. This method, however, proved very laborious, and was abandoned later. Instead, the seedlings were weighed and the average weight in milligrams calculated. In some instances the average dry weight was also determined. All experiments were repeated a number of times.

PROOF OF THE EXISTENCE OF GERMINATION INHIBITING SUBSTANCES IN THE TOMATO FRUIT

The failure of cereal grains to germinate in the presence of tomato juice may be attributed to a number of causes, such as (1) oxygen deficiency, (2) high osmotic value of juice with respect to seed, (3) an accumulation of acid in the juice, or (4) the presence of special germination-inhibiting substances.

(1) *Oxygen deficiency.* This factor may be eliminated at once, as in every experiments the seeds investigated were exposed to air during the entire course of our work.

(2) *High osmotic pressure of the juice.* The question arises as to whether the osmotic pressure of the fruit-juice is such as to prevent the diffusion of water into the seed, thus maintaining the seed in a state of physiological dryness.

The osmotic pressure of various samples of tomato-juice was determined cryoscopically, and was found to vary between 8 and 10 atmospheres. We decided to perform germination experiments in a number of solutions isotonic with tomato-juice, because a study based on the use of one solution could have been misleading

owing to specific effects. The sugar content of the juice was therefore analysed and as determined by the colorimetric method of Folin-Wu, totalled between 5 and 8%, of which 2—3% were reducing and 3—5% were non-reducing. The sulfo-salicyl test for protein gave negative results. As an example of our experiments on the effect of osmotic pressure, we may cite the following :

Wheat grains were germinated :

A. In tomato juice (osmotic pressure 8.4 atm.) and in dilutions 1 : 2, 1 : 5, and 1 : 10 (two or four dishes to each dilution, as stated in section on technique).

B. In sucrose solution isotonic with juice and in respective dilutions.

C. In glucose solution isotonic with juice and in respective dilutions.

D. In KNO_3 isotonic with juice and respective dilutions.

E. In KCl isotonic with juice and in respective dilutions.

F. In NaCl isotonic with juice and in respective dilutions.

G. In water as control.

The results obtained are given in the accompanying Table 1.

This experiment, which was repeated several times and under varying conditions shows clearly that the osmotic pressure does exert an influence on germination. An increase in pressure retards development and slackens the rate of germination. However, the final percentage of germinated seeds remains unaffected. Even judged by the effect on development and germination rate osmotic pressure is only of secondary importance. Experiments, to be described later lend additional support to our conclusion. Even at a dilution of 1 : 5 in which the osmotic effect is scarcely perceptible, tomato juice sometimes almost completely inhibits germination. This fact clearly brings out the effect of factors other than osmosis. The following experiment serves our point :

A. Wheat grains were germinated in juice and at juice-dilutions of 1 : 2, 1 : 5 and 1 : 10.

B. Barley grains were germinated as above.

C. *Sinapis* seeds, were germinated as above.

Wheat, barley and *Sinapis* seeds were germinated separately in water for control.

Table I
Influence of osmotic pressure upon germination of wheat

Conc. of juice	Days	Sets																	
		A			B			C			D			E			F		
		a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c
Undiluted juice	2	0			48			88			2			6			0		
	4	0			94			98			96			92			94		
	7	6	22	4	94	15	4	98	28	5	98	43	7	98	43	6	98	30	4
1:2	2	8			96			90			46			72			50		
	4	30			98			96			98			98			100		
	7	46	36	5	98	34	6	96	32	6	98	84	10	98	93	10	100	73	9
1:5	2	16			100			92			88			80			74		
	4	48			100			100			100			98			100		
	7	88	50	5	100	59	10	100	59	10	100	80	12	98	107	12	100	93	11
1:10	2	34			100			92			86			74					
	4	70			100			98			96			100					
	7	100	94	11	100	79	12	98	83	12	100	104	16	100	93	11			

a denotes the percentage of germinated grains;

b denotes average fresh weight of one seedling in mg.

c denotes average dry weight of one seedling in mg.

Days — denote the number of days since the beginning of the experiment.

Results are given in Table 2.

Table 2

The effect of the osmotic pressure of juice on various seeds

Conc. of juice	Days since beginning of exp.	Sets		
		A	B	C
Undiluted juice	2	0	0	0
	3	0	0	0
	6	0	0	0
1 : 2	2	0	0	0
	3	0	0	0
	6	0	0	0
1 : 5	2	0	0	0
	3	8	8	0
	6	20	8	0
1 : 16	2	22	16	0
	3	38	20	0
	6	64	20	4
Water	2	78	76	46
	3	90	80	80
	6	94	84	84

Figures represent the percentage germination.

(3) *The effect of pH on germination.* Measured colorimetrically, the pH of tomato-juice is 3.8. We were led to suspect, therefore, that the inhibition of germination is caused by the acidity of the juice.

A first series of experiments consisted in germinating seeds at different pH's in the pH range from 1 to 6. The experiments were carried out in standard solutions, as prescribed by SOERENSEN. In addition, seeds were germinated in neutralised tomato-juice using 5.9 cc. N/1 NaOH for every 100 cc. tomato-juice. Our experiment proved that acidity influences germination but slightly. Also the inhibitory effect is only very slightly weakened by neutralisation. (Table 3).

Table 3

The effect of neutralised juice on germination

Sets	Days since beginning of exp.	Concentration of juice				
		Undiluted	1 : 2	1 : 5	1 : 10	1 : 25
A	1	0	0	0	4	8
	2	0	0	2	34	46
	3	0	26	78	92	96
B	1	0	0	0	0	8
	2	0	0	22	16	64
	3	0	0	82	92	96
C	1	4				
	2	45				
	3	92				

A. Wheat grains germinated in neutralised juice and in dilutions.

B. Wheat grains germinated in untreated juice and in dilutions.

C. Wheat grains germinated in water as control.

Figures represent percentage germination.

(4) *Germination in sterilised juice.* Tomato juice is an excellent medium for the development of moulds and bacteria; these alter the chemical and physical qualities of the juice. In our experiments the juice was occasionally contaminated and the observation was sometimes made that in contaminated juice inhibition was less marked than when the juice remained clear. Nevertheless, it was considered desirable to ascertain whether the inhibition is caused by the action of moulds or bacteria. Experiments were therefore conducted in sterilised juice.

Tomato-juice was sterilised by filtration through a Seitz filter. The seeds were sterilised following the method of БАЕХМИ: the seeds were placed in a current of sterile water containing traces of NaOH, swelling thereby. They were then placed in potassium hypochlorite solution for three hours, washed in sterile water, and transferred aseptically into sterile Petri dishes. The dishes remained sterile for four days. Germination was inhibited, as in contaminated juice. The development of the seedlings, however, was less affected than in contaminated juice.

Together with other authors (OFFENHEIMER 1922 a, b; REINHARD 1933) we conclude, therefore, that the tomato fruit contains substances which act as germination inhibitors. While other factors may alter the inhibitory effect, they are, nevertheless, only of secondary importance.

THE PROPERTIES AND ACTION OF THE GERMINATION INHIBITOR

(1) *Localisation.* The tomato-fruit consists of the flesh proper and a dense liquid immediately surrounding the seeds. Experiment revealed that the latter exerts a stronger inhibiting effect than the flesh proper, though the difference is only slight. The inhibiting factor, therefore, is distributed throughout the fruit.

It has also been found that upon filtration of the tomato-juice, the inhibitor passes wholly into the filtrate; the residue of coarse pinkish particles, when washed, dried and suspended in water, did not inhibit the germination of seeds.

(2) *Specificity.* In our experiments tomato-juice inhibited the germination of wheat, barley, oat and maize grains. Its action, therefore, is non-specific. However, the degree of inhibition varied according to the kind of seeds employed, the degree of decreasing effect being,

oats > barley > wheat > maize.

(3) *Experiments on dialysed juice.* In order to find out whether the inhibitor particles are colloidal or not, the following experiment was conducted:

Wheat grains were germinated in juice dialysed for 1 day (Set A), 2 days (Set B), 3 days (Set C), 4 days (Set D), and 5 days (Set E). In addition, wheat grains were germinated in tomato juice + 25% water¹ (Set F), and in water (Set G) for control.

Juice dialysed for 1 day showed a strongly positive Fehling reaction, was acidic and turbid (owing to precipitated colloids). Following dialysis for 2 days, however, the juice was negative both with respect to reducing and non-reducing sugars, and acid, turbid, and colourless.

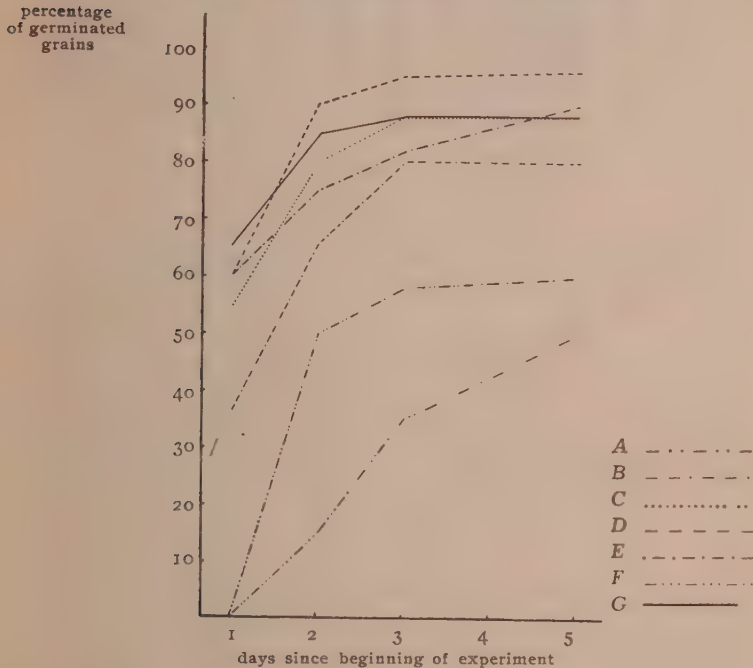
The results of the experiment are given in Figure 1. It is seen that the more prolonged the dialysis, the less marked is the inhibitory effect as judged by the rate of germination and the total number of germinated grains. The rate of seedling development, shows the same as proven by the following numbers which denote

¹ During the dialysis the volume of the juice increased by about 25 per cent. For purposes of comparison a proportional volume of water was added to undialysed juice as well.

the average fresh weight of one seedling in mg. $A=11$, $B=45$, $C=50$, $D=50$, $E=75$, $F=8$, $G=73$.

Figure 1

The influence of dialysed juice on germination



Another difference between the effect of dialysed and undialysed juice is that seeds germinating in the latter were always badly deformed (thickened radicles, abnormal elevation of embryo from seed, disproportionate growth of coleoptile). No deformations were observable in seeds germinated in dialysed juice.

(4) *Effect of concentration.* Wheat grain was germinated in juice and at the dilutions 1:2, 1:4, 1:8, 1:15, 1:30, 1:60, 1:125, 1:250, 1:1000, also in water for control (Table 4).

Wheat grain was also germinated in dialysed juice and at the dilutions 1:2, 1:4, 1:8, 1:16, 1:30, 1:60, 1:125, 1:250, 1:1000 (Table 5 and Figure 2).

Table 4
The effect of various juice dilutions on germination

Days	Concentration of juice												Water
	Undiluted	1:2	1:4	1:8	1:15	1:30	1:60	1:125	1:250	1:1000			
a	b	a	b	a	b	a	b	a	b	a	b	a	b
1	0	0	0	0	2	—	10	—	6	10	—	8	—
2	0	10	80	80	94	—	98	—	100	100	—	100	—
7	4	35	30	65	100	90	98	97	100	96	98	98	80

a denotes the percentage of germinated grains;
b denotes average fresh weight of one seedling in mg.
Days denote the number of days since the beginning of the experiment.

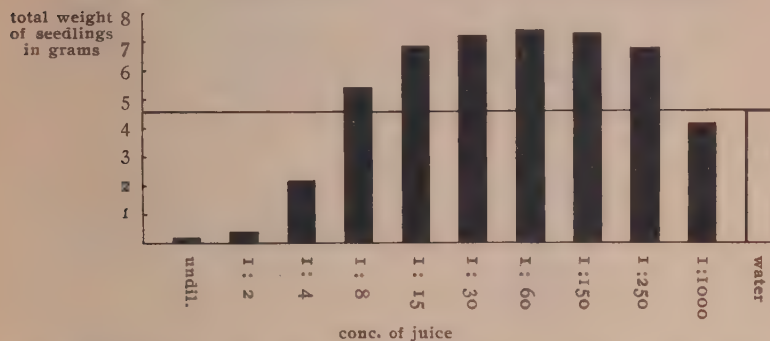
Table 5
The effect of various dilutions of dialysed juice on germination

Days	Concentration of juice												Water
	Undiluted	1:2	1:4	1:8	1:16	1:30	1:60	1:125	1:250	1:1000			
a	b	a	b	a	b	a	b	a	b	a	b	a	b
2	5	7	30	—	56	—	84	—	98	—	100	—	64
3	10	10	50	—	77	—	92	—	100	—	100	—	90
4	12	17	20	19	60	36	90	98	70	100	72	100	49

a denotes the percentage of germinated grains;
b denotes average fresh weight of one seedling in mg.
Days denote the number of days since the beginning of the experiment.

Figure 2

The effect of various dilutions of dialysed juice on germination



The blocks represent the total weight of seedlings in grams of fresh weight after 7 days; thus gauging the action of juice by all three criteria adapted, namely final germination percentage, germination rate and seedling development.

A perusal of the tables shows clearly that :

(a) The inhibition is less marked at high dilutions, gradually disappearing.

(b) At sufficiently high dilutions the inhibition is replaced by a stimulation.

(c) The stimulation is more pronounced in dialysed than in undialysed juice.

(d) The dependence of effect upon dilution may therefore be represented as an optimum curve. In this connection it may be mentioned that our experiments on the effect of heteroauxin on the germination of wheat grain have shown that varying concentrations act in exactly the same manner. For confirmation we repeated our experiments a large number of times. In general it may be stated that the stronger the inhibiting action of the undiluted juice, the less marked is the stimulation at high dilutions.

(5) *Effect of temperature on juice.* On this point opinions differ. We therefore conducted experiments with a view to investigating the matter thoroughly.

Our technique consisted in heating the juice in stoppered bottles in a water-bath for one hour at certain temperatures. The following experiments were performed :

(a) On dialysed juice (Table 6 and Figure 3). The juice was dialysed for 24 hours. Wheat grains were germinated

A. In dialysed juice, which had been heated to 60°C, and in dilution 1:2.

B. In boiled dialysed juice and in dilutions as above.

C. In unheated dialysed juice and in dilutions as above.

D. In water for control.

Table 6

The effect of heated and boiled juice on the germination of wheat

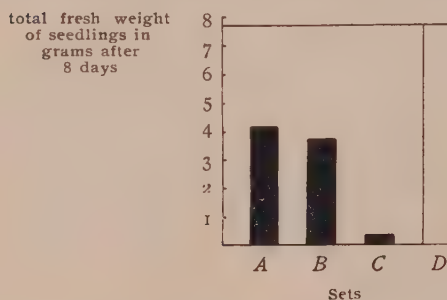
Concentration of juice	Days since beginning of exp.	Sets							
		A		B		C		D	
		a	b	a	b	a	b	a	b
Undiluted	2	15	—	13	—	0	—	50	—
	3	54	—	32	—	0	—	80	—
	5	70	—	53	—	5	—	83	—
	8	78	53	68	54	15	25	90	85
1:2	2	30	—	30	—	35	—	—	—
	3	80	—	80	—	66	—	—	—
	5	100	—	98	—	80	—	—	—
	8	100	85	98	85	80	95	—	—

a denotes the percentage of germinated grains;

b denotes average fresh weight of one seedling in mg.

Figure 3

The effect of heated and boiled juice on the germination of wheat



(b) Undialysed juice (Table 7). Heating was carried out as described. However, when it was desired to boil the juice, this was done near an open flame under a reflux condenser.

Barley grains were germinated :

- A. In juice heated to 60°C and in dilutions 1:2, 1:5.
- B. In boiled juice and in dilutions as above.
- C. In unheated juice and in dilutions as above.
- D. In water for control.

Table 7

The effect of heated and boiled juice on the germination of barley

Concentration of juice	Days since beginning of exp.	Sets			
		A	B	C	D
Undiluted	2	48	16	0	76
	3	48	16	0	80
	6	48	16	0	84
1:2	2	42	24	0	
	3	50	24	0	
	6	60	26	0	
1:5	2	80	66	4	
	3	80	66	8	
	6	92	68	8	

Figures represent the percentage germination.

Judged by the three criteria (rate, final percentage of germination, seedling development) germination is more strongly inhibited in unheated, than in previously heated juice.

It appears, therefore, that the inhibitor is thermolabile. However, it is a remarkable fact that germination in boiled juice was more pronounced than in juice heated to 60°C. Our experiments were repeated numerous times, results always agreeing.

(6) *Effect of juice on the capacity of seeds to germinate.* In order to study the effect, if any, seeds were placed in juice under varying conditions and subsequently transferred to water. Wheat, oat, maize and barley grains were placed for two (Set A), 24 (Set B), and 50 (Set C), hours in undiluted tomato juice. Wheat and barley grains were also placed for 24 and 50 hours in juice at a dilution of 1:2 (Sets D and E respectively) and in boiled juice (Sets F and G respectively). Wheat, barley, oats and maize grains were germinated in water and in juice as controls (Sets H and I respectively). Following such treatment the seeds were

transferred to Petri dishes for germination in water. The results of these experiments are found in Table 8, and for wheat and barley shown graphically in Figure 4.

Table 8

The effect of juice on the capacity of seeds to germinate

Kind of grains	Days after transfer of seeds	Sets								
		A	B	C	D	E	F	G	H	I
Wheat	1	4	0	0	30	0	20	4	18	0
	2	54	26	0	82	0	78	18	78	0
	3	66	—	—	—	—	—	—	90	0
	4	80	46	0	88	0	92	25	90	0
Barley	1	6	4	0	22	0	56	2	30	0
	2	18	4	0	22	0	60	16	73	0
	3	24	—	—	—	—	—	—	82	0
	4	36	6	0	32	0	70	20	90	0
Oat	1	2	24	0	—	—	—	—	54	0
	2	20	28	0	—	—	—	—	90	0
	3	22	—	—	—	—	—	—	90	0
	4	32	34	0	—	—	—	—	96	0
Maize	1	5	23	5	—	—	—	—	6	0
	2	43	43	13	—	—	—	—	88	1
	3	73	—	—	—	—	—	—	100	10
	4	80	58	18	—	—	—	—	100	14

Figures represent the percentage germination.

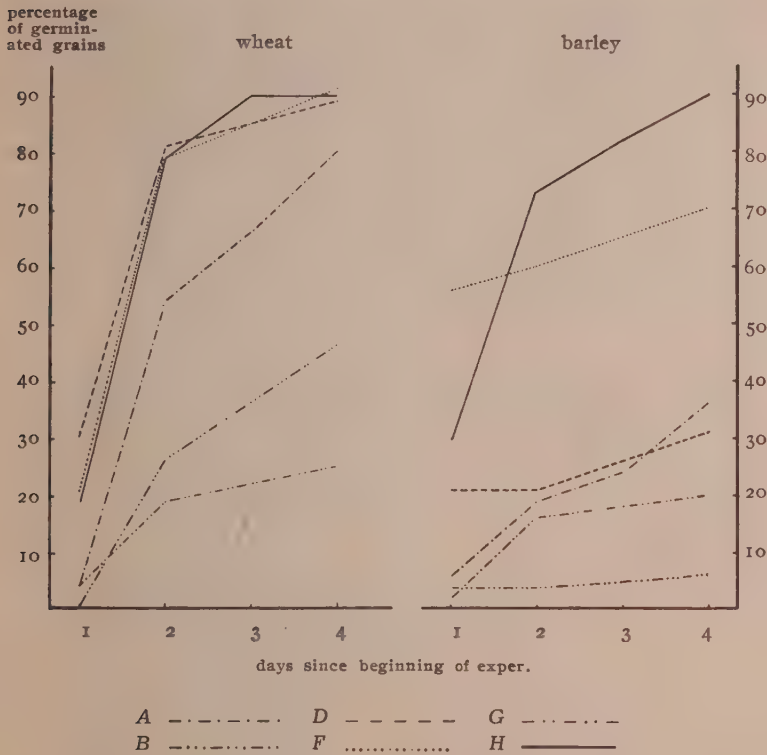
Contact with tomato-juice, therefore, greatly impairs the capacity of grain to germinate. Even after contact of short duration (e.g. two hours) germination in water is retarded; prolonged contact (fifty hours) renders the grain entirely incapable of subsequent germination. Maize, it will be noted, is less susceptible than other grain.

In dilute juice the effect is less marked. Here, too, however, contact for fifty hours renders the grain incapable of subsequent germination.

Boiled juice impairs the capacity for germination only to a slight measure, even though the effect is more pronounced after prolonged contact. All these facts corroborate our findings on the thermolability of the inhibitor and the effect of dilution.

Figure 4

The effect of juice on the capacity of wheat and barley grain to germinate



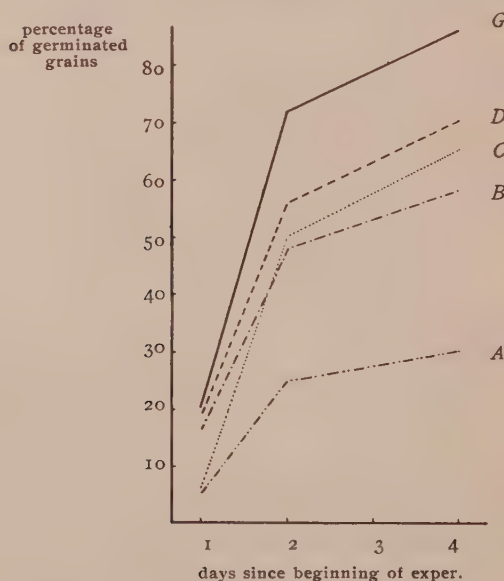
In C, E and I no germination at all.

(7) *Effect of juice on seedlings at different stages of development.* Here seeds were transferred from water to juice. Our experiments revealed that tomato-juice exerts an inhibitory effect in all the stages of seed development. Seedlings in an advanced stage of development continue to sprout leaves, but their radicles blacken and degenerate. Well developed maize, however, continues developing almost normally. Boiled or diluted juice has no effect on transferred seeds, which continue their development in a normal manner.

(8) *Adsorption of inhibitor.* We have been able to confirm the finding of VAHL (1940) that the inhibitor may be adsorbed on animal charcoal. However, the entire removal of inhibitor was not feasible, and even after adsorption for three days and three hours shaking, inhibition was perceptible. On boiling juice previously subjected to adsorption the effect disappeared almost entirely. Among other experiments the following is illustrative.

Barley grains were germinated in juice previously subjected to adsorption and at a dilution of 1:2 (Sets A, B). Barley grains were germinated in juice treated as above which was boiled afterwards (Set C); the same juice at a dilution of 1:2 (Set D). Wheat grains were germinated in untreated juice in its dilution of 1:2 (Sets E, F) and in water (Set G). Results may be read from Figure 5.

Figure 5
The influence of juice after adsorption with animal charcoal



In E and F no germination at all.

(9) *Volatility.* The discovery by VAHL (1940) of the volatile nature of the germination-inhibitor present in *Poterium spinosum*, and the repeatedly expressed opinion (BORRIS 1936,

DENNY and MILLER-LAWRENCE 1935, KOECKEMANN 1936, LAIBACH u. KEIL 1937, MOLISCH 1937) that certain life-processes, including germination, are influenced by gaseous products, led us to inquire as to the volatility of the germination-inhibitor studied. The following experimental method was employed: For each germination test the base of one Petri dish was placed concentrically in another of larger diameter. In the smaller dish, seeds were germinated on water-moistened filter-paper, while the space between the two dishes contained the substance whose action it was desired to investigate. Filter-paper, for the absorption of moisture, was fitted into the inner side of a Petri-dish cover of sufficient size which was placed over the two concentrically-arranged dish bases. Thus more or less closed atmospheres were obtained which contained the volatile elements of the liquids investigated. Using this technique, wheat grains were germinated in 'juice,' 'boiled juice,' and 'water' atmospheres (Sets A, B and C respectively).

Another set consisted in arranging three Petri-dish bases concentrically, with wheat grains in the central circle, animal charcoal in the first 'ring,' and juice in the second (Set D). Seeds were also germinated in contact with juice for control (Set E). Our results are produced in Figure 6.

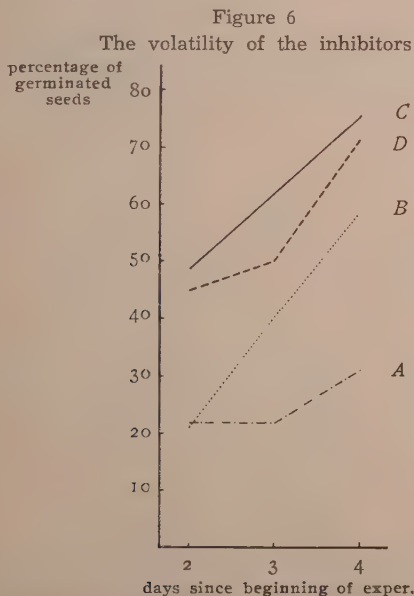


Plate I shows seeds germinated in a 'juice' atmosphere and in a 'water' atmosphere.

It is evident that the inhibiting agent present in tomato-juice acts on seeds even in the absence of direct physical contact. Thus the inhibitor is volatile. Animal charcoal is capable of adsorbing the inhibitor even when the latter is in the gaseous state.

10. *Effect of external conditions.* Seeds were germinated at room temperature, in a thermostat at 26° C and at 30° C, in light and in the dark. These varying conditions exerted no perceptible effect on the inhibition and, consequently, on the inhibiting factor.

THE MODE OF ACTION OF THE INHIBITING FACTOR

As a prerequisite to the understanding of the mechanism involved in germination-inhibition, the isolation of the 'active principle' is essential. In so far as such attempts have failed, any explanation which may be advanced is largely hypothetical.

Germination involves imbibition and swelling of the seed, the breakdown of food reserves, respiration and growth. The disturbance of any one of these processes may explain the inhibition of germination.

(1) *Imbibition and Swelling.* In Table 9 and Figure 7 the swelling of seeds in water and juice is recorded. Swelling in juice occurs only to a slightly lesser degree than in water; in all probability, this difference is due to the different osmotic pressures of the germination media, and is decidedly of no import in explaining the inhibition.

Table 9

The swelling of barley and oat grain in juice

Hours since beginning of swelling	Kind of grain					
	barley			oat		
	in juice	in water	difference	in juice	in water	difference
2	16,5	18,5	10,8	20,2	22,2	9
24	37,2	42,1	11,5	42	47,1	10,8

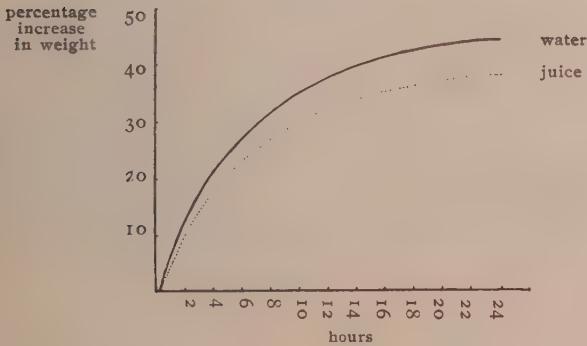
Figures represent percentage increase in weight.

(2) *Respiration.* According to OPPENHEIMER the inhibiting factor acts as a negative catalyst in the respiratory processes of the seed. We have put this explanation to a test by placing a weigh-

ed quantity of seeds in juice, dialysed juice¹ and water, respectively, for 24 hours, and measuring their respiration intensity. As a measure of this quantity, the amount of liberated CO₂, determined eudiometrically, was taken. The respiration intensity of the seeds placed in untreated juice was found to be lower by only about 10 per cent than the water control, which, in turn, had an intensity lower than the value for dialysed juice, also by about 10 per cent. Our experiments, therefore, do not support the explanation suggested by OPPENHEIMER.

Figure 7

The swelling of wheat grain in juice



(3) *Breakdown of food reserves.* As is well known, at the time of germination stored food materials are broken down in the endosperm and their component units are transported to the loci of development where they are rebuilt into living tissue. In the *Gramineae* the most important enzyme responsible for this breakdown is diastase. To test whether the inhibitor directly affects the enzymes responsible for food breakdown the activity of diastase was examined in juice and in aqueous suspension for control. The method employed was crude, though results showed clearly that the addition of juice to diastase did not alter the activity of the enzyme.

¹ The juice had been dialysed for one day.

The remaining process involved in germination, namely growth, is to be regarded as an outcome of the other three. We therefore omitted to experiment on the direct effects of tomato juice on growth.

Thus, our efforts to understand the mechanism underlying the inhibition of germination have so far yielded negative results. We are still at a loss as to the true nature of the processes involved.

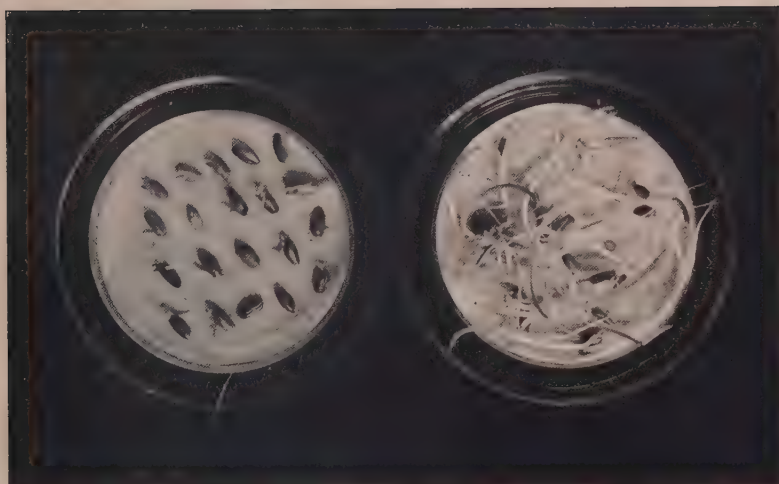
DISCUSSION

The inhibition of germination, generally accepted as a mechanism against precocious germination, was first considered by OPPENHEIMER (1922 a, b) as due to the action of inhibiting substances occurring in the fruit. The evidence furnished by OPPENHEIMER to this effect was corroborated by other authors (BORRIS 1936, FUKAKI 1930, KOECKEMANN 1934, 1936, REINHARD 1933). We hereby confirm this conclusion. While other factors, osmotic pressure and acidity, do influence germination to some extent, they are only secondary in importance. By far the major rôle is played by an inhibiting substance of a non-specific character.

The inhibition, if not total, is marked by a reduced number of germinating seeds, a reduced rate of germination, and a greatly retarded rate of seedling development. The entire seedling, especially the radicles, is deformed. These become short, thicken and blacken and the embryo becomes abnormally elevated with respect to the seed.

The juice inhibits the growth of seedlings in all stages of their development. Its action is strong and contact with the seed for as short a period as two hours greatly affects subsequent germination. The effect varies with the concentration of the juice disappearing at sufficiently low concentrations. At still lower concentrations a stimulatory effect makes its appearance: germination and seedling development are more rapid than in the water-control. With diminishing concentration the stimulation reaches a maximum and then declines gradually until it disappears. Thus dependence of germination on concentration may be represented graphically as an optimum curve.

The effect of concentration may be viewed as a resultant of two factors, the one stimulative and the other inhibitory. The former is less sensitive to dilution than the latter, and is therefore apparent at high dilutions only. This relationship, together



A

B

Wheat grains germinated A in a "juice" atmosphere and B in a
"water" atmosphere.

with the observation that dialysis removes the inhibiting factor while the capacity for stimulation is retained, may indicate that two separate factors are involved. However, we are in no position to make any definite statement, as several other hypotheses may be advanced on the same factual basis.

As regards the mechanism underlying the inhibitory effect, information is scant. Attempts to explain it on the basis of imbibition phenomena, an inability to utilise food reserves or an inhibition of respiration have failed. Possibly, the inhibition is due to an inactivation of the hormones responsible for germination (RUGE 1939).

As revealed by our experiments, the inhibitor is of a volatile character, crystalloidal, thermolabile, being destroyed even at a temperature of 60° C.

This our findings on the thermolability of the inhibiting factor agree with those of OPPENHEIMER (1922 a, b). A noteworthy fact is the greater susceptibility of the inhibitor to a temperature of 60° C than to 100°. A possible explanation might lie in the resistance of the stimulating factor to 60° but not 100°, at which temperature it ceases to counteract the inhibition. The fact that boiled juice does not lose its inhibiting properties entirely may be explained on the basis of secondary factors, namely osmotic pressure and the acidity.

The inhibitor is adsorbed on animal charcoal from solution as well as from a gaseous milieu.

While the determination of the chemical structure of the inhibitor is outside the scope of our investigation, it may be mentioned that the volatility of the inhibiting agent may serve as a key to its identification. The discovery of the volatile nature of the germination inhibitor renders more plausible the ideas advanced by MOLISCH (1937), and LAIBACH und KEIL (1937). Whether the inhibitor be HCN derived from nitrite-glucosides by the action of emulsin, as is contended by LAIBACH and KEIL (1937), or whether it be ethylene (MOLISCH 1937) or some other volatile compound, we cannot tell. However, the suggestion of DENNY and MILLER (1935) that ethylene is given off from tomato-fruits and the effect of ethylene on development and germination, so very similar to that of tomato-juice (MOLISCH) are highly suggestive.

CONCLUSIONS

(1) The existence of a substance or substances in the tomato-fruit which inhibit germination is proved.

(2) The effect of osmotic pressure and acidity on the inhibition of germination have been studied and shown to be of secondary importance.

(3) The inhibitor is thermolabile. It may be adsorbed on animal charcoal, is non-colloidal, volatile.

(4) In the presence of the inhibitor, germination, if any, is greatly reduced and retarded, and seedling is deformed. Under the influence of the inhibitor, the development of normal seeds is also greatly retarded.

(5) The activity of the inhibitor is a function of concentration. Increased dilution diminishes the inhibition, until it disappears entirely. At very high dilutions this inhibition is replaced by a stimulation. A stimulation of germination is also observed following prolonged dialysis of tomato-juice.

(6) The inhibitor exerts no appreciable effect on imbibition and swelling of the seed, respiration or the activity of diastase.

(7) External conditions affect the activity of the inhibitor but slightly.

* * *

The author takes this opportunity of expressing his deep gratitude to Dr M. EVENARI for his constant guidance and useful advice.

REFERENCES

- BORRIS, H. (1936). Ueber das Wesen der keimungsfoerdernden Wirkung der Erde. *Ber. dtsch. bot. Ges.* 54:472-486.
- DENNY, F. E. and MILLER-LAWRENCE, P. (1935). Production of ethylene by plant tissue as indicated by the epinastic response of leaves. *Contr. Boyce Thompson Inst.* 7:97-102.
- EVENARI, M. (1940). On Germination-Inhibitors. I. Introduction. *Palest. Journ. Bot. J Series*, 2:1-5.
- FUKAKI, S. (1930). Ueber die Frage der Beeinflussung des eigenen Fruchtsaftes auf die Samenkeimung. *Bull. Sci. Fac. Terkult. Kjusu Imp. Univ.* 4.

- KOECKEMANN, A. (1934). Ueber eine keimungshemmende Substanz in fleischigen Fruechten. *Ber. deutsch. Bot. Ges.* 52:523-526.
- (1936). Zur Frage der keimungshemmenden Substanz in fleischigen Fruechten. *Beih. Bot. Ctrlbl. Abt. A*, 55:196.
- LAIBACH, F. und KEIL, J. (1937). Ueber die keimungshemmende Wirkung der freien Blausaeure. *Ber. deutsch. bot. Ges.* 55:579-583.
- MOLISCH, H. (1937) *Der Einfluss einer Pflanze auf die andere. Allelopathie.* Jena.
- OPPENHEIMER, H. (1922a). Keimungshemmende Substanzen in der Frucht von *Solanum Lycopersicum* und in anderen Pflanzen. *Sitz. Ber. Wien. Akad. Wiss. Abt. I*, 131:59-65.
- (1922 b). Das Unterbleiben der Keimung in den Behaeltern der Mutterpflanze. *Sitz. Ber. Wien. Akad. Wiss. Abt. I*, 131:279-312.
- REINHARD, A. W. (1933). Zur Frage der Samenkeimung bei *Solanum Lycopersicum*. *Planta*. 20:792-794.
- RUGE, U. (1939). Zur Physiologie der genuinen keimungshemmenden und beschleunigenden Stoffe von *Helianthus annuus*. *Ztschr. Bot.* 33:529.
- VAHL, I. (1940). On germination inhibitors. III. Germination inhibitors in the fruit of *Poterium spinosum* L. *Palest. Journ. Bot. J Series*, 2:28-32.

ON GERMINATION INHIBITORS

III. GERMINATION INHIBITORS IN THE FRUIT OF *POTERIUM SPINOSUM* L.

By I. VAHL

(With 1 figure in the text)

In our investigation on the biology of *Poterium spinosum* we encountered difficulties in germinating seeds enclosed in their fruit. The germination of *Poterium* seeds, whose fruit coats had been removed was found to be considerably more rapid than when the seeds were enclosed in their fruit coat. The question arose, therefore, as to the presence within the fruit coat of factors which inhibit germination, as in the case of the tomato.

The fruit of *Poterium spinosum* is a drupe, whose parenchymatous flesh encloses three seeds. The developing seedlings penetrate the fruit coat at the point of attachment of fruit to pedicel.

EXPERIMENT i

Generally, seeds free of fruit coats germinated some days earlier and to a greater degree than seeds enclosed in their fruit (see Table 1). This difference in germination was found to be more striking in winter than in summer. We have to point out that hardly ever all the 3 seeds inside the fruit coat germinate — one or two usually failing to do so.

EXPERIMENT ii

We then desired to find out whether the inhibitory effect was due to the presence of definite inhibitors or to an insufficient diffusion of water and oxygen through the coat. We therefore punctured the fruit coat at the point at which the seedling would develop, thus ensuring contact with water and oxygen. As a result, the number of seeds to germinate increased slightly, though the delay remained as marked as before. We were led therefore to the second alternative, namely that the fruits contain a substance or substances which inhibit germination.

EXPERIMENT iii

Enclosed seeds were germinated in Petri dishes as follows :

- (1) On moist filter paper ;
- (2) On soil, on which *P. spinosum* had previously grown.

Table 1 (Experiment i)

Time (since beginning of experiment)	Germination of seeds free of fruit coat	Germination of seeds inside fruit coat
5	3	0
6	5	0
7	6	2
8	7	2
9	11	5
10	15	6
11	18	8
12	23	12
13	29	16
14	35	18
15	37	23
16	42	30

Remarks: (a) The seeds free of fruit coats were spread on the Petri dishes, 3 seeds to a group, as inside the fruit. (b) In each Petri dish we put 50 such groups. (c) The numbers given above are the number of groups in which germination occurred and not the number of single seeds germinated. (d) We repeated this experiment many times, always obtaining the same results.

Germination on/soil was found to occur sooner and to a greater degree than on moist filter paper. In the latter case, the number of fruits in which all three seeds germinated was greater too.

The results of similar experiments on boiled soil did not differ in any respect from the above. The analogy of the results to those obtained by BORRIS (1936) for *Vaccaria pyramidata*, led us to test his assumption, namely, that suitable adsorbents are capable of removing the inhibitor.

EXPERIMENT iv

Germination experiments of enclosed seeds were carried out on animal-black, with controls on moist filter paper. It was found that (1) germination occurred sooner and more rapidly on animal-black than in filter paper, and (2) the difference between the two sets is very conspicuous at the start and gradually diminishes with time.

As a working hypothesis we assumed that carbo animalis, in virtue of its adsorptive power, removes the inhibitor.

We decided, therefore, to try the method of selective adsorption and thus gain more knowledge as to the nature of the inhibiting substance.

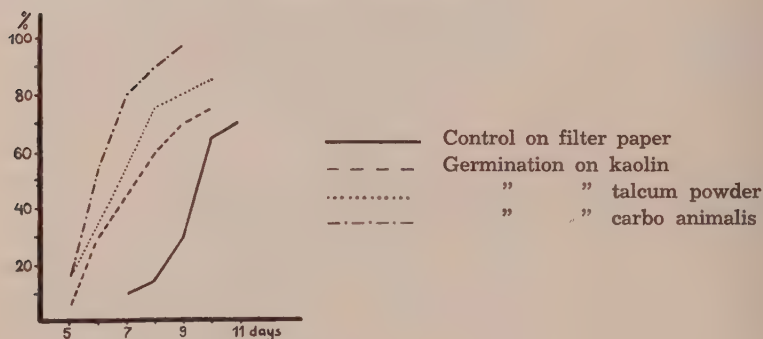
EXPERIMENT v

Enclosed seeds were germinated in Petri dishes :

- (1) On kaolin,
- (2) On animal black,
- (3) On talcum powder,
- (4) On filter paper (control).

An inspection of the figure shows that enclosed seeds germinated earlier and to a greater degree in the presence of animal charcoal, talcum powder or kaolin than on moist filter paper. The difference between the curves is greatly noticeable at the start and gradually diminishes with time.

Figure (Experiment v)



EXPERIMENT vi

It has been suggested by BORRIS (1936) that the inhibitor in *Vaccaria pyramidata* is a volatile substance. We have therefore performed the following experiment in order to clarify this point.

Thin layers of animal charcoal were spread over the bottom of Petri dishes. Absorbent gauze was then stretched over the brim, and on it enclosed seeds were placed for germination. Suitable controls were prepared exactly as above, except that here the bottom layer of animal charcoal was missing (see Table 2). Germination in those dishes containing charcoal appeared one and half to two days earlier than in the controls — and to a higher degree. This experiment proves that the inhibitor is volatile as BORRIS (1936) opines for *Vaccaria pyramidata*.

Table 2 (Experiment vi)

Time (since beginning of experiment)	Germination of seeds on dishes containing charcoal	Germination of seeds on dishes not containing charcoal
6	2	0
7	4	2
8	9	4
9	10	6
11	12	7
12	15	8
13	19	10
14	25	15
16	30	21
17	36	29
18	44	33

EXPERIMENT vii

The purpose of this experiment was to determine, whether the fruit coat exerted its inhibitory influence only at the point where the seedling develops (see p. 28) or on the entire surface of the seed. In one group of seeds the coats were stripped except at the point of development; in the other group, the coats were left intact. Experiments revealed that seeds of the former group germinated sooner and to a greater extent than those of the latter, thus showing that the entire surface of the fruit coat exerts an inhibitory effect.

EXPERIMENT viii

In order to determine whether the used adsorbentia are specific only for the inhibitor of *Poterium* or may remove the inhibiting factor present in other plant fruits too we performed the following experiments: Carbo animalis was added to tomato juice which contains an inhibitor acting on wheat grains (see p. 6). Then germination experiments were conducted on wheat seeds as follows:

- (1) On filter paper wetted with tomato juice which had previously been subjected to adsorption by animal charcoal;
- (2) On filter paper wetted with untreated tomato juice;
- (3) On filter paper moistened with water.

We observed that in (1) and (3) germination was simultaneous and occurred earlier than in (2). In (1), however, the progress of germination was somewhat slower than in (3).

CONCLUSIONS

- (1) The fruit of *Poterium spinosum* contains a substance or substances inhibiting germination.
- (2) Suitable adsorbents (as charcoal or talcum powder) adsorb and remove the inhibitor from the fruit.
- (3) The inhibitor seems to be of a volatile nature.

REFERENCE

- BORRIS, H. (1936). Ueber das Wesen der keimungsfoerdernden Wirkung der Erde. *Ber. dtsh. bot. Ges.* 54 : 472-486.

ON GERMINATION INHIBITORS

IV. GERMINATION INHIBITORS OF *SINAPIS ALBA* AND OTHER SEEDS WHEN ENCLOSED IN THEIR FRUIT

By RACHEL SROELOV

(With 2 figures in the text)

The majority of investigations on germination inhibitors have concerned themselves chiefly with fleshy fruits. The object of this work has been to determine whether such inhibitors exist in dry fruits as well. On the basis of certain preliminary experiments, we have selected chiefly members of the *Cruciferae* for study, especially *Sinapis alba* L.

The fruit of *Sinapis alba* is composed of valves and beak. The valves contain 1—3 seeds and are dehiscent. The beak is flattened, sable-shaped, bears one seed and is indehiscent.

The following observations brought us to believe in the presence of germination inhibitors in the fruit coats of *Sinapis alba*:

In spring, in the vicinity of blossoming *Sinapis alba* plants we observed closed and rotting *S. alba* beaks enclosing seeds which did not germinate. We have been unable to find closed valves owing to the fact that when the beak detaches itself from the valves the latter dehisces.

EXPERIMENT 1: *Sinapis alba* L. (see Figure 1)

All experiments on germination have been carried out as follows: 4 Petri dishes, each containing 25 seeds on moistened filter paper were employed for each experiment.

In our tables we shall use the following signs:

d — Number of days from the beginning of the experiment.

A₁ — Percentage of valve-seeds free of fruit coats which have germinated since the beginning of the experiment.

B₁ — Percentage of beak seeds free of fruit coats which have germinated since the beginning of the experiment.

A₂ — Percentage of valve seeds within their open valves which have germinated since the beginning of the experiment.

B₂ — Percentage of beak seeds within their open beaks which have germinated since the beginning of the experiment.

B₃ — Percentage of beak seeds enclosed in their beaks which have germinated since the beginning of the experiment.

Figure 1

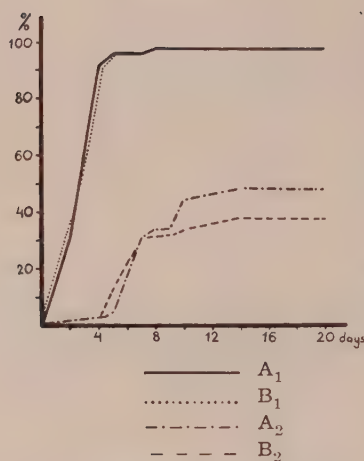
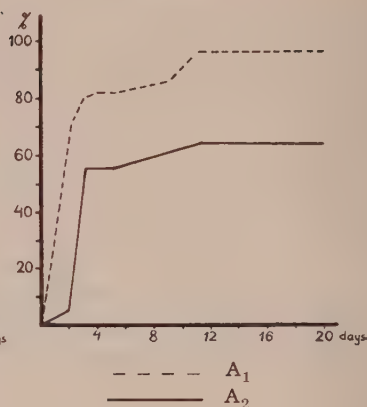


Figure 2



In B₃ no germination at all.

EXPERIMENT ii: *Erucaria Boveana* Coss.

Lettering as in Exp. i.

d	A ₁	B ₁	A ₂	B ₂	B ₃
1	0	0	0	0	0
2	0	20	0	0	0
3	34	32	20	34	0
4	38	48	22	34	0
5	40	52	22	34	0
6	48	60	28	34	0
8	48	68	34	34	0
10	50	68	34	34	0

(The experiment has been discontinued on the 10th day owing to contamination by fungi).

EXPERIMENT iii: *Matthiola bicornis* S. et S. (see Figure 2)

A₁ — Percentage of seeds free of fruit coats which have germinated since the beginning of the experiment.

A₂ — Percentage of seeds within their fruit coats which have germinated since the beginning of the experiment.

From these 3 experiments it is seen (1) that seeds enclosed in their beaks fail to germinate, and (2) that the fraction of seeds to germinate when near their fruit coat is much smaller than the fraction which germinates in the absence of fruit-coats.

EXPERIMENT iv: *Ephedra campylopoda* C.A.M.

In order to prevent contamination by fungi some drops of thymol were added to the dishes. After 28 days all seeds free of fruit coats germinated. Within the open fruits there was no germination at all.

In the following experiments we have tested the presence of germination inhibitors in beak and valve extracts of *Sinapis alba*.

EXPERIMENT v: *Sinapis alba* L.

5 grams of beaks and valves respectively were allowed to stand in 50 cc. tap-water for an hour and were subsequently filtered. The filter-papers in the Petri dishes were then moistened with the brownish-yellow filtrate.

Germination experiments were conducted in 6 Petri-dishes, each containing 25 seeds and 4 layers of filter-papers.

In this experiment:

a₁ — Percentage of valve-seeds which germinated since the beginning of the experiment in water-moistened filter-paper.

b₁ — Percentage of beak seeds which germinated since the beginning of the experiment on water-moistened filter-paper.

a₂ — Percentage of valve-seeds germinated on filter-paper moistened with the extract of valves.

b₂ — Percentage of beak seeds germinated on filter-paper moistened with the extract of beaks.

a₃ — Percentage of valve seeds germinated on filter-paper moistened with the extract of beaks.

b₃ — Percentage of beak seeds germinated on filter-paper moistened with the extract of valves.

d	a ₁	b ₁	a ₂	b ₂	a ₃	b ₃
1	0	0	0	0	0	0
2	34	32	0	0	0	0
4	90	90	1	0	3	2
5	92	92	14	2	5	20
6	92	96	30	4	6	37
7	92	96	46	6	8	48
11	98	96	68	26	26	62
14	98	98	76	36	54	76
15	98	98	76	36	54	76
18	98	98	80	44	60	82
21	98	98	80	46	62	82
25	98	98	80	48	62	82
30	98	98	80	48	62	82

EXPERIMENT vi: *Sinapis alba* L.

1 gram of valves, pedicels and beaks respectively was allowed to stay in 100 cc. tap-water for 21 hours and was subsequently filtered. The extract was then diluted to the original volume. In each series, 100 seeds were treated with extract.

In this experiment:

a_1 — Percentage of valve-seeds on water-moistened filter-paper which germinated since the beginning of the experiment.

a_2 — Percentage of valve-seeds germinated on filter-paper moistened with the extract of beaks.

a_3 — Percentage of valve-seeds germinated on filter-paper moistened with the extract of valves.

a_4 — Percentage of valve-seeds germinated on filter-paper moistened with the extract of pedicels.

d	a_1	a_2	a_3	a_4
2	18	3	0	1
3	64	37	8	17
4	84	60	50	44
5	84	80	73	82
6	84	83	82	90
10	88	85	85	97

It is seen from the last two experiments that inhibition is marked whenever seeds of valves or beaks were treated with the extract of valves, beaks or pedicels.

In the following experiments we tested the thermostability of the inhibitors.

EXPERIMENT vii: *Sinapis alba* L.

5 grams of valves and 5 grams of beaks respectively were boiled in 50 cc. water, for $\frac{1}{2}$ hour. Germination experiments were conducted as described in the previous experiments. Parallel experiments were also performed using in one case unboiled extract and in the other water.

a_1 — Percentage of valve-seeds which germinated since the beginning of the experiment on water-moistened filter-paper.

b_1 — Percentage of beak-seeds which germinated since the beginning of the experiment on water-moistened filter-paper.

a_2 — Percentage of valve-seeds germinated on filter-paper moistened with the extract of valves.

b_2 — Percentage of beak seeds germinated on filter-paper moistened with the extract of beaks.

a_3 — Percentage of valve-seeds germinated on filter-paper moistened with the extract of beaks.

b_3 — Percentage of beak seeds germinated on filter-paper moistened with the extract of valves.

c_1 — Percentage of valve-seeds germinated on filter-paper moistened with boiled extracts of valves.

e_1 — Percentage of beak seeds germinated on filter-paper moistened with boiled extracts of beaks.

c_2 — Percentage of valve-seeds germinated on filter-paper moistened with boiled extract of beaks.

e_2 — Percentage of beak-seeds germinated on filter-paper moistened with boiled extract of valves.

d	a ₁	b ₁	a ₂	b ₂	a ₃	b ₃	c ₁	e ₁	c ₂	e ₂
1	0	0	0	0	0	0	0	0	0	0
2	44	32	3	4	0	12	0	0	0	0
5	74	68	16	6	4	36	41	8	15	24
6	74	68	28	8	9	44	44	13	18	36
8	74	68	40	12	12	48	53	16	24	41
10	74	68	48	26	22	51	57	19	24	43

SUMMARY

(1) *Sinapis alba*, *Erucaria boveana* and *Matthiola bicornis* seeds do not germinate within their closed beaks.

(2) When free of fruit coats the valve-seeds and the beak-seeds show no difference in their capacity to germinate.

(3) The number of seeds to germinate when near their fruit coat or within the open fruit is much inferior to that which germinates when the seeds are germinated in the absence of fruit coats.

(4) *Ephedra campylopoda* seeds fail to germinate within the open fruit, and are capable of germinating only when entirely outside it.

(5) The valves and beaks of the afore-cited plants contain a substance which inhibits the germination of seeds when enclosed in them.

(6) In the case of *Sinapis alba* the germination inhibitor in the beaks exerts a stronger effect than the germination inhibitor in the valves.

(7) The pedicels too contain a germination inhibitor, which, however, is much less efficient than that of valve and beak.

(8) In the case of *S. alba* experiments have shown that the inhibitors are thermostable and water-soluble.

(9) The inhibitory effect increases with increasing concentration of extract.

THE ACTION OF DIPHENYL ON *PENICILLIUM* AND *DIPLODIA* MOULDS

BY A. FARKAS AND J. AMAN

(With 5 figures in the text)

The inhibiting action of diphenyl vapours on the growth of *Trichoderma viride* and *Penicillium digitatum* was discovered by TOMKINS (1935) who utilized this action in designing a method for the prevention of decay of citrus fruit. His method consists of impregnating the citrus wrappers with diphenyl. As subsequent experiments indicated (FARKAS, 1938, 1939) that TOMKINS' method offers a reliable and practical means for the prevention of wastage of citrus on a commercial scale, it seemed desirable to investigate the action of diphenyl on fungi in some detail. The purpose of this paper is to report on these experiments.

EXPERIMENTAL

The fungi under investigation were *Penicillium digitatum*, *Penicillium italicum* and *Diplodia* sp.¹, as these organisms are chiefly responsible for the wastage of citrus fruit in Palestine. The experimental technique used was the same as that used by TOMKINS. The fungi were grown on a culture medium in Petri dishes (diameter 7 cm., height 4 cm., or diameter 10 cm., height 1.5 cm.) and the diphenyl was introduced in a small dish in the form of crystals (in certain cases in the form of a solution) into the Petri dishes in such a way that only the vapours of it could come into contact with the culture. The size of the culture was measured daily and in each case the growth of the fungi in the presence of diphenyl was compared with the growth in the absence of diphenyl.

In these experiments the peptonic medium², the media of RAULIN-DIERCKX, and of CZAPEK, were used (SMITH, 1938). Furthermore, in order to make the culture media resemble as far as possible the natural medium present on citrus fruit, experim-

¹ Dr I. REICHERT of the Jewish Agency Agricultural Research Station in Rehovot was kind enough to supply the *Diplodia* fungi.

² 10g. peptone, 20g. glucose, 5g. meat extract, 25g. agar per 1 liter water.

ents were performed with the following media: (1) extract of orange peels + 2% agar; (2) ditto, but extract filtered; (3) as 2 with 5% glucose; and (4) extract of albedo + 2% agar.

The growth of the fungi was measured at a constant temperature of 20 or 25°C. The form of the colony was usually circular. The diameter of the circular colonies increased linearly with the time and therefore it was found convenient to express the size of the colony always by the diameter. In the case of slightly elliptical colonies, the geometrical means of the larges and smallest diameters was taken as a measure for the size while with more irregular colonies, the area was determined. From this, the diameter of the corresponding circle was calculated.

ACTION OF DIPHENYL ON THE FUNGI GROWTH ON PEPTONIC MEDIA

The development of the three fungi under investigation in the absence and in the presence of diphenyl is shown in Figures 1, 2 and 3. It will be recognized that in each case the growth of the fungi stopped nearly completely after the introduction of the diphenyl, but set in with normal speed as soon as the diphenyl was removed from the dishes. This observation indicates that while diphenyl vapour at a concentration corresponding to the vapour pressure of diphenyl at room temperature inhibits the development of the fungi, it does not kill the fungi. Furthermore, it follows from these experiments that the culture medium does not

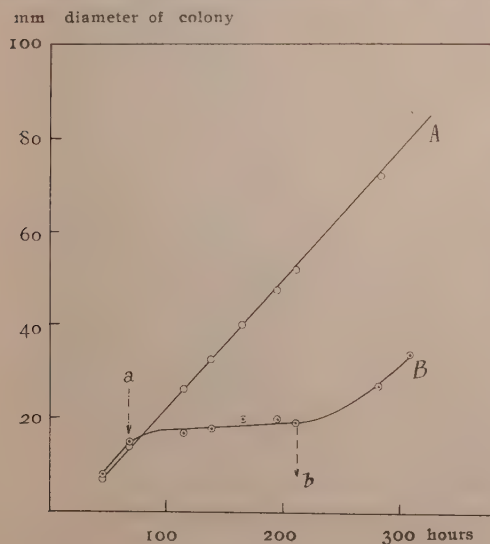


Figure 1. *Penicillium digitatum*.

Curve A: Growth in the absence of diphenyl.

Curve B: Growth in the presence of diphenyl.

a: diphenyl added,

b: diphenyl removed.

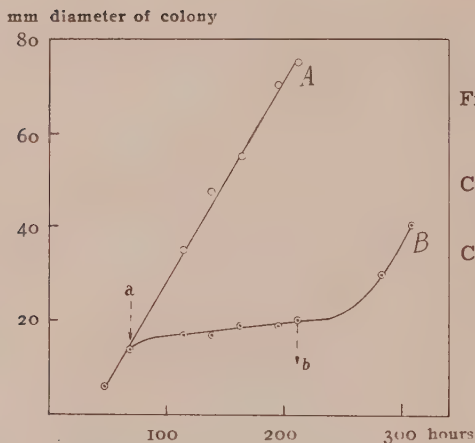


Figure 2. *Penicillium italicum*.

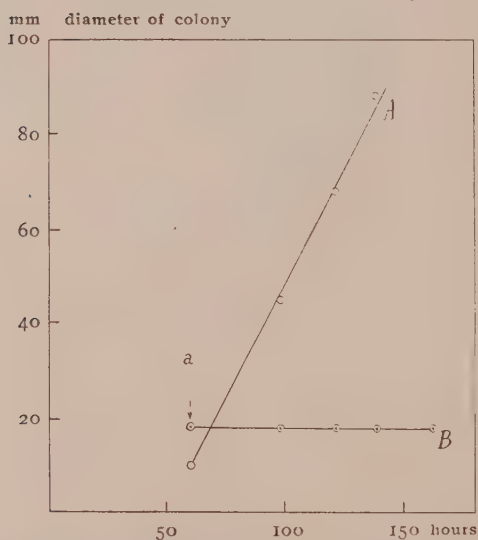


Figure 3. *Diplodia* sp.

dissolve nor adsorb practically any diphenyl since otherwise the growth would not have set in immediately upon removing the diphenyl from the dish.

In all these experiments the diphenyl was introduced after the colony had attained a diameter of several millimeters. In the diphenyl is introduced immediately after the inoculation, no visible colony is formed within a week.

VARIATION OF THE CULTURE MEDIA

Using the culture media of RAULIN-DIERCKX, of CZAPEK, and

media prepared from orange peels, exactly the same results were obtained with regard to the action of diphenyl as with peptonic media. Some characteristic experiments with *P. digitatum*, for example, are shown in Table I.

TABLE I

Temperature 21°C. Diameter of the dish 70mm. The diameter of the colonies is given in mm. The + sign indicates the addition of diphenyl.

Hours	RAULIN-DIERCKX		CZAPEK		Medium 2		Medium 1		Medium 3	
0	0	0	0	0	0	0	0	0	0	0
44	—	—	—	—	11	11	7	5	4	6
70	15	11	10	10 +	27 +	25	30 +	30	30 +	29
93	30 +	20	20	20	30	36	31	45	30	50
139	30	45	40	20	31	60	33	60	33	60
163	30	45	—	20	30	—	33	—	35	—

It will be recognized that in each case the growth of the fungi was considerably reduced or even stopped after the addition of diphenyl.

Vapours of diphenyl inhibit the development of the *Penicillium* moulds in a liquid medium also, as is shown by the following experiments. Twenty days after sowing the fungi on a liquid peptonic medium in a vessel 7 cm. in diameter, only slight signs of growth were observed in the presence of diphenyl vapours. In the control vessel without diphenyl, the surface of the liquid was completely covered with fungi as early as the fourth day.

VARIATION OF THE CONCENTRATION OF DIPHENYL VAPOUR

The inhibitive action of diphenyl is due to the amount of diphenyl vapour present in the atmosphere in which the moulds are growing. The highest concentration of diphenyl which can be attained over solid diphenyl is given by the vapour pressure of diphenyl. According to MACK (1925) the vapour pressure of diphenyl is 0.0085 mm. Hg at 25°C. In good agreement with this figure, the present authors obtained the following values using a quartz fibre manometer (cf. FARKAS and MELVILLE, 1939):

0°C	0.0017 mm Hg
15°C	0.0047 " "
25°C	0.0096 " "

In view of the long duration of the experiments and the restricted possibility for diphenyl vapour to escape from the petri dishes, it is most probable that the air inside the Petri dishes is in fact saturated with diphenyl vapour. At a temperature of 25°C the vapour pressure of diphenyl corresponds to a concentration of 0.08 mg. of diphenyl in one litre of air. At this relatively low concentration, the moulds are unable to develop further.

In order to have the possibility of varying the concentration of diphenyl vapour in the Petri dishes, a series of experiments was performed using solutions of diphenyl instead of crystals. In these experiments, butylphthalate was used as a solvent because its vapour pressure can be neglected in comparison with that of diphenyl, it has no effect on the growth of the fungi, and it dissolves 27% diphenyl by weight. These experiments are represented in Figures 4 and 5. The results obtained indicate that a con-

mm diameter of colony

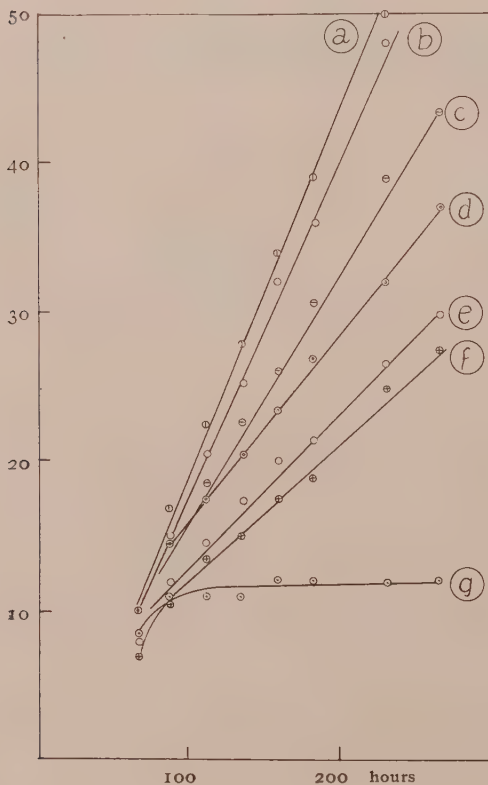


Figure 4. Growth of *Penicillium digitatum* in the presence of diphenyl in various concentrations:

- a : 0.000 mg / liter
- b : 0.007 " "
- c : 0.010 " "
- d : 0.014 " "
- e : 0.017 " "
- f : 0.020 " "
- g : 0.080 " "

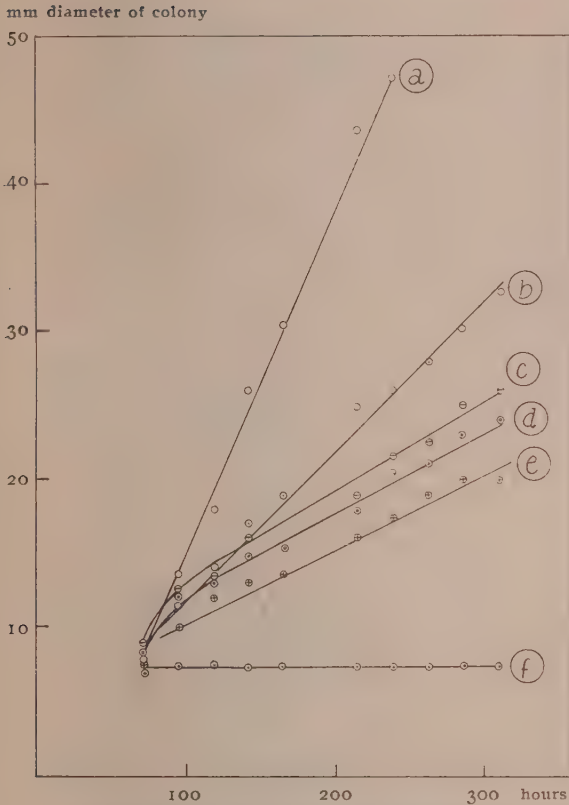


Figure 5. Growth of *Penicillium digitatum* in the presence of diphenyl in various concentrations:

- a: 0,000 mg / liter
 b: 0,020 " "
 c: 0,030 " "
 d: 0,036 " "
 e: 0,052 " "
 f: 0,080 " "

centration of 0.014 mg. of diphenyl per liter of air is sufficient to reduce the rate of growth of the fungi to half, and that a concentration of 0.03 mg. diphenyl per liter cuts down the rate of growth to one quarter.

ISOLATION OF A RESISTANT STRAIN OF *Penicillium digitatum*

It was repeatedly observed that having been in contact with diphenyl for some weeks, the *Penicillium digitatum* started to grow even in the presence of diphenyl. This new growth set in rather suddenly and developed concentrically around a certain point of the circumference of the culture. If some spores taken from the additional growth were sown into fresh agar, the growth of this culture was no longer inhibited by diphenyl. In one series of experiment, it was found that this insensitiveness to diphenyl was inherited even to the third generation. The appearance of

cultures thus obtained was similar to, but not identical with, that of the original *Penicillium digitatum* cultures. In this manner a resistant strain was isolated, the exact nature of which deserves further investigation.

MICROSCOPIC OBSERVATIONS

The experiments with the cultures showed that though by the action of diphenyl the development of the fungi was inhibited, the fungi was not actually killed. For this reason, the action of diphenyl on single spore culture of *P. digitatum* was examined under the microscope.

The cultures for microscopic examination were prepared on a cover glass which was attached to the microscope slide by means of a glass ring. Thus it was possible to expose the cultures to diphenyl vapour by introducing a small crystal of diphenyl into the space between the cover glass and the slide.

At 25°C in the absence of diphenyl the spores of *P. digitatum* germinate in about 7 to 13 hours, while in the presence of diphenyl no germination took place within 72 hours. After removing the diphenyl the spores usually germinated within a day.

If the diphenyl was added after the spores had germinated, no hyphal growth could be detected. In the absence of diphenyl the hyphae grew at a rate of 40 μ to 80 μ per hour. On removing the diphenyl, young hyphae showed no signs of further development while older hyphae, the growth of which was arrested at a stage near to that of spore formation, soon bore fresh spores.

The observations made on *P. digitatum* most probably apply to other moulds and indicate that diphenyl vapour can only kill the younger hyphae while it retards the germination of spores and further development of older hyphae.

ACKNOWLEDGEMENTS

The authors are greatly indebted to the Pardess Syndicate of Palestine Citrus Growers Co-operative Society Ltd., for a grant which made this research possible. Their thanks are also due to Dr R. G. TOMKINS of the Low Temperature Research Station, Cambridge, for some useful advice and for supplying cultures of the *Penicillium* moulds, and to Dr T. RAYSS of the Botanical Department of the Hebrew University for many helpful hints for dealing with moulds and for her interest in these experiments.

SUMMARY

The action of diphenyl vapour on *Penicillium digitatum*, *Penicillium italicum* and *Diplodia* sp. has been investigated on various culture media. The development of these fungi is completely stopped at a concentration of 0.08 mg per liter of air, which correspond to the vapour pressure of diphenyl at 25°C. A concentration of 0.014 mg diphenyl in a liter of air is sufficient to reduce the rate of growth of *Penicillium digitatum* to half the normal value. By exposing the cultures of *Penicillium* moulds for some weeks to diphenyl vapour, a strain resistant to diphenyl has been isolated. By microscopic observation it is found that diphenyl vapour can only kill young hyphae, while spores and older hyphae are able to develop further as soon as the diphenyl has been removed.

REFERENCES

- FARKAS, A. (1938). The Practical Application of Impregnated Wrappers Against Fungal Decay of Citrus Fruit. *Hadar* 11: 184-189, 261-267.
— (1939). Control of Wastage of Citrus Fruit by Impregnated Wrappers on a Commercial Scale. *Hadar* 12: 145-148, 227-231.
— and MELVILLE, H.W. (1939). *Experimental Methods in Gas Reactions*. London, 91.
MACK, E. JR. (1925). Average Cross Sectional Area of Molecules by Gaseous Diffusion Methods. *Journ. Am. Chem. Soc.* 47: 2468.
SMITH, G. (1938). *An Introduction to Industrial Mycology*. London. 219-220.
TOMKINS, R.G. (1935). Wraps for the Prevention of Rotting of Fruit. *Report Food Investigation Board* 1935: 129-131.

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GEOBOTANICAL ANALYSIS OF THE SYRIAN DESERT

By M. ZOHARY

(With Plates II, III, IV and 1 map)

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INTRODUCTION

The present paper deals with the flora and vegetation of the Syrian Desert, which is botanically very little known. It is regrettable indeed that among the famous explorations made during the last and present centuries in Northern Arabia and the adjacent parts of the Syrian Desert, botany was almost completely ignored.

Nevertheless, a summary of the botanical data available for this Desert, including our own findings, for the purpose of outlining the phytogeographical subdivision and the vegetational character of this country would not be premature at this juncture.

This paper cannot, of course, claim to give a complete account owing to the fact that some of the existing data are very fragmentary and not always reliable, and more particularly because considerable tracts of this Desert are still botanically unexplored. Future work may therefore add much interesting material and change some details of this preliminary outline.

This paper is based for the most part on our own observations made on geobotanical journeys, mostly together with the late Dr ERG, the eminent geobotanist of the Near East, to whom I am much indebted for some suggestions made during our travels. An abundant phytosociological material collected in these and other journeys will be published later in the *Reliquiae Eigianae*.

GENERAL PART

(i) *Geographical limits*

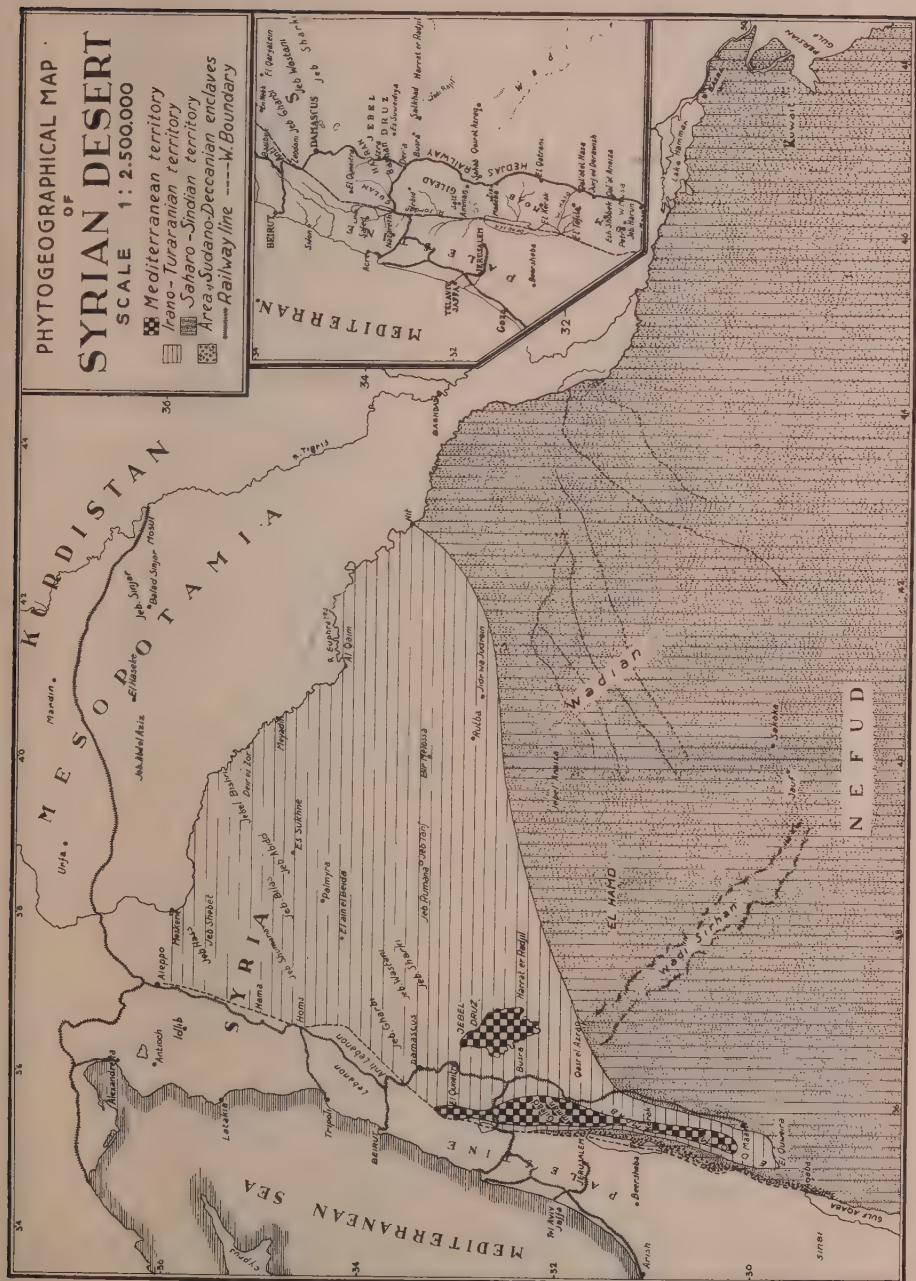
The Syrian Desert, in its wide geographical sense, consists of a triangular area, the base of which lies on the 30th parallel of N. Lat. and the apex in the environs of Aleppo. It is bounded in the East by the Euphrates River and in the West by a line drawn from 'Aqaba along the Wadi 'Araba, the Jordan Valley, the eastern slopes of the Hermon and Antilebanon and the Homs Aleppo line¹ (see accompanying map). While the eastern and western limits can, to a certain degree, be regarded as physical

ones, the southern is only an ethnographical or political one. Some geographers move this boundary as far northward as Palmyra, others — southward to the latitude of Jebel Shammar. RITTER (1852), HOGARTH (1904), LESCH (1930), GRANT (1937), however, recognise for the southern boundary a line drawn between the Gulf of Suez and the Persian Gulf. This is strongly supported also by landscape features, as the latter limits form an approximate line of demarcation between the huge sand-dune zone of the Nefud and Dahana and the zone of the Hamd. Except for the north-western boundary (Hermon-Aleppo) which here forms the limit between the Mediterranean and the Irano-Turanian region, none of these boundary-lines mentioned coincide with biogeographical lines. Nevertheless, we must look upon the Syrian Desert as a biotic unit and treat it as a whole regardless of its political divisions governed by Syria, Iraq, Saudia and Transjordan.

(ii) *Oro- and hydrography*

The Syrian Desert exhibits a plateau of an average height of about 700 m., gently sloping towards the East and South East. Along its western boundary it is fringed by a series of higher mountains of which the following may be mentioned: Mount Seir, the highest summit of which reaches ca. 1600 m. The 'Jbal Mountain with a maximum altitude of 1400 m. The mountains of Moab, Gilead and the solitary elevations of Golan, reach a height of about 1300 m. (Um el Daraj, Tel es Schesha, Tel abu en Nada). East of the Golan the Hauran occupies a good part of the desert. It consists of the very fertile Bashan plain and the mountainous Jebel Druz with its summits attaining a height of 1800-1900 m. In the Syrian part the Desert is bounded in the

¹ It is true that, for historical and ethnographical reasons, some parts of Transjordan can not be included within the Syrian Desert. But since the purpose of this paper is to find out the phytogeographical boundaries of a phytogeographically rather obscure area it appears to us practical to follow GRANT (1937) and other authorities in accepting the Jordan River as the only physically well marked western boundary of the Syrian Desert. By doing so, the phytogeographical survey becomes much clearer than by applying historical and ethnographical boundaries not generally acknowledged.



West by Mt. Hermon and the Antilebanon, whose highest summits reach about 2700 m. Further north the boundary passes through the basalt plain of the Hama district of an average height of about 500 m. Along the Euphrates river the altitude decreases toward the South reaching the sea level at Basra. The northern part of the Syrian Desert (the Palmyrena or the "Little Desert") is orographically much more differentiated than the southern one. Significant for this part is a series of mountains running in a SW-NE direction. This mountain range is an eastern branch of the Antilebanon, and further to the East it splits into three separate chains: Jebel Gharbi, Jebel Wastani and Jebel Sharki. The latter, the southernmost and longest chain, reaches the Euphrates and attains a maximum altitude of 1850 m. North of this triple Palmyrenian range there is another series of mountains running nearly in a WE direction, of which Jebel Bilas, Jebel Shumaria and Jebel Abiad are the most important. The triangular Palmyra basin or the Palmyra desert is enclosed between these mountains and the Palmyrenian ranges. North of the Shumaria-Abiad range the plateau turns into a vast, almost level land, interrupted here and there by solitary elevations arranged in a NW-SE direction. Most of these elevations are of volcanic origin, so Jebel Hass, Jebel Amiri and Jebel Shebet. The valleys and water courses are badly drained here, and give rise to a number of Sabkhas or salt marshes, such as: il Malh, il Sabkha (S. of Aleppo) and others.

The southern part of the Syrian Desert is orographically less complex. It coincides partly with the Arabia Deserta as understood by MUSIL (1927), and may be subdivided into three main districts: (1) The Hauranian massive, comprising the basaltic Golan, the Bashan, Dīr e Tulul, Jebel Druz, and Harrat er Rajil. (2) El Hamd or Badiet esh Sham, being the largest and most desolate part of the interior Arabia Deserta, including also Jebel Anaize, which here forms the main watershed. (3) The Wadian, which is the eastern part of this desert, distinguished by its comparatively dense network of Wadis running towards the Euphrates, of which only a few reach the River. South of the Hauran the long depression of Wadi Sirhan extends in a NW-SE direction, and somewhat easterly to its southern end the oases Jauf and Sakaka are situated at the northern foot of the Great Nefud.

Summarizing we may say: (1) The marginal mountains on the western border are to a certain degree accountable for the desolation of large tracts of the interior plain. The fact that the northern part of the desert is much less desolate than the southern part is not only the result of its geographical latitude, but also of its orographical relations. This part is not overshadowed by high mountain walls, as is the case with the "hinterland" of the southern desert. (2) The floristic and vegetational richness of the northern part and its abundance in endemic forms seems likewise to be to a certain extent a result of the orographical diversity of this part, producing a series of habitats, which are scarcely or not at all represented in the southern part. (3) The fact that the interior of the Syrian Desert, although divided up into a rich network of valleys and wadis, does not exhibit any permanent water course is vegetationally most significant. The hydrophytic vegetation, richly developed along the Euphrates, the Jordan river and other marginal water courses is lacking entirely in the interior. The numerous wadis which run dry in the midst of the desert account for the accumulation of salty marshes and development of a halophytic flora. On the other hand many ephemeral wadis play an important role in the plant life of the desert on account of their edaphic peculiarity. Being the only seat of vegetation in immense barren stretches, they form the centres of distribution and preservation for the desert flora element.

(iii) *Geology and soil diversity*

Concerning the geology of the Syrian Desert we mention here only a few facts, which are connected with plant distribution and plant life.

Together with Arabia, the Syrian Desert represents, as is well known, a part of the African table-land separated from Arabia at the young Tertiary by the formation of the great longitudinal fault system, extending between the Orontes and Sambezi River. The existence of a depression, about 400 m. below sea level in the Jordan Valley, resulting from these faults, is the main reason for the deep penetration of the Saharo-Sindian element into this Valley. The special climatic and edaphic conditions prevailing in the Valley also made possible the existence of a series of Sudano-Deccanian plants within it.

According to DUBERTRET (1933), BLANCKENHORN (1914), and others, the largest part of the northern Desert is covered by Senonian and Miocene rocks, while in the central part the Eocene-Oligocene is predominant. In comparison with the distribution of the Senonian-Tertiary limestone, the Cenomanian and Turonian rocks are rather limited. These layers cover the so called Palmyrenian range as well as the greatest part of the Jebel Shumaria—Jebel Abiad plateau, and are frequently encountered in the marginal mountains of Transjordan.

The following occurrences are also vegetationally important :

(a) Granite and other crystalline rocks limited to the SW corner (environs of Quweira-Aqaba); (b) Nubian Sandstone, abundant not only in the southern part of Transjordan, but extending also, according to BLUNT (1881), over a large tract in the southern Hamd and on both sides of Wadi Sirhan; (c) the eruptive rock consisting of dark basalts of Neogen-Quaternary origin. The latter is very abundant in the Syrian Desert, occupying the whole of the Hauranian massifs (Golan, Bashan, Jebel Druz, Dīr e Tulul, Harrat er Rajil) and is encountered also intermittently in the NW part of the Desert (Homs, Hama, Aleppo districts).

As to diversity of soils, the following types may be distinguished here :

(1) Soft greyish steppe soil. This is the most common soil type in the Syrian Desert, being the product of weathering of the Senonian, Eocene and Miocene limestone. It is distinguished by its whitish grey colour, its exceedingly high content in lime (CaCO_3 —30-72%) and the almost complete lack of humus. It is alkaline (pH—7,6-8,6), possesses a high amount of fine sand (30-60%) and clay (20-45%). It is highly penetrable for water and is well aerated.

(2) Flinty Hammadas (gravel lands). As a result of the selective weathering of the Senonian and Eocene rocks, a great deal of the land in this country is covered with black flint pebbles or gravel, the vegetation of which is extremely poor. This type of soil is found for example, between Amman and el Azraq, in Moab and in Edom. The ecological relation of this Hammada type is not adequately known. (Plate III C).

(3) Terra rossa. As a product of weathering of the Cenomanian and Turonian rock, we obtain a reddish-brown soil of the Mediterranean terra rossa type. This soil consists generally

of a smaller amount of lime (10-40%) and some humus. It is more compact, less aerated, less penetrable for water and more moist than the grey steppe soil. It is limited in the Syrian Desert chiefly to the Mediterranean territory and occurs in the northern part of the Desert also in Irano-Turanian conditions, where it also permits the development of an arboreal plant association.

(4) Basalt soils. According to the rate of weathering we may subdivide the basaltic ground of the Syrian Desert into the following types: (a) Basalt rock. We observed this type only in the Jebel Druz; it is quite unfertile. (b) Harra. This is a "soil" of black basalt boulders, met with in our district at Harrat er Rajil, in some parts of the Golan etc. Vegetationally these districts are extremely barren. There are transitions from the Harra to the basalt Hammada, i.e. to the basalt gravel lands. (c) Mature basalt soils. This soil type is limited only to the western edge of the Desert, where the conditions of weathering are more favourable. It is abundant in the Bashan, as well as in the Homs-Hama district. Though a highly fertile and an agriculturally valuable soil type, it seems to be less suitable for tree growth than terra rossa. Where it is intermingled with calcareous soil its fertility seems to be higher because of the better aeration. (d) Basalt dust. In the environs of Tel Shihan (N Jebel Druz) we met with a tract of calcareous grey underground covered by a very thin layer of basaltic fine dust protecting the undersoil from excessive evaporation.

(5) Sandy soils. The main sources of the widely distributed sandy soils are the so-called Nubian Sandstone and the igneous rocks (mainly granite), abundant chiefly in the southwestern part of the Desert. In Edom we met with large tracts of sandy fields which are the product of the weathering of Nubian Sandstone. They are inhabited by a Saharo-Sindian psamphytic flora. In the SE corner of the Syrian Desert (Basra-Sulbie-Ur) we met with a type of packed sandy soil covered or intermixed with fine gravel. There is some evidence that this soil is transported from the Nubian Sandstone of the Jauf and Sakaka region. Sandy soil is also widely distributed in dry wadies e.g. Wadi Rajil, Wadi Sirhan, Wadi Ithm, etc.

It is doubtful whether there exists a continuous sand dune region within the limits of the Syrian Desert accepted in this paper. We ourselves met with solitary dunes in Edom

(weathering product of granite dominated by *Haloxylonetum persici*) and in the environs of Jaliba W of Basra (dominated by *Calligonetum comosi*). According to the descriptions of MUSIL (1927) and other explorers it seems that some higher dunes exist in the environs of Jauf and Sakaka.

(6) Of the other soil types mention may be made of the Sabkhas, the salty marshes limited to more or less closed valleys, depressions, inundated regions of the Euphrates and the Dead Sea Valley and certain badly irrigated lands. These salt marshes are centres of a halophytic vegetation of the Syrian Desert, which, with the exception of that of the Dead Sea, is rather poor here in comparison to that in other countries of the Near East (Iraq, Iran, Baluchistan).

(7) Gypseous soils. These we encountered chiefly in the district of Deir-e-Zor and Palmyra. A well distinguished plant association is confined to this soil. (See p. 76).

We have quoted here some striking soil types, common in the Syrian Desert, in order to show the diversity of the edaphic conditions of this desert country, and the resulting diversity in the vegetation units dealt with later on.

(iv) Climate

Our records on the climatological conditions are very scanty; we especially lack such data from the interior part of the country.

The Syrian Desert, like its adjacent countries is distinguished climatically by its short winters and long, hot and dry summers. Together with Mesopotamia it forms a level land closed towards the North, West and East by more or less high mountain ranges, which give to the country a somewhat continental climate. With the exception of the SE edge, which is influenced by the climate of the Persian Gulf, and the Indian Ocean, and which is in this regard more favoured than the inner parts, the whole of the Syrian Desert obtains its precipitations from W and NW.

According to its position precipitations not only diminish in amount as we advance towards E and S, but also become irregular. Judging from the behaviour of vegetation in the central part there is some evidence that in these part rainfall does not occur every year. So, for instance, between Rutba and Ramadi we encountered in the flowering season considerable patches of *Artemisia Herba alba* and *Poa sinaica* whose aerial parts were

dead or nearly dead. These plants being most characteristic for the central part of the desert seem to be adapted to this irregularity of rainfall by their ability to endure several rainless years in a geophytic state.

The following tables were calculated from the records of the (1) Meteorological Department of the Hebrew University (ASHBEL, 1930; 1938), (2) Meteorological reports of the Iraquian Government, and (3) Bulletin Mensuel de Service Central Meteorologique, Ksara (Syria). Although fragmentary and incomplete, the data give us a general idea of the climatic conditions of this country, and provide an explanation of some striking vegetational phenomena.

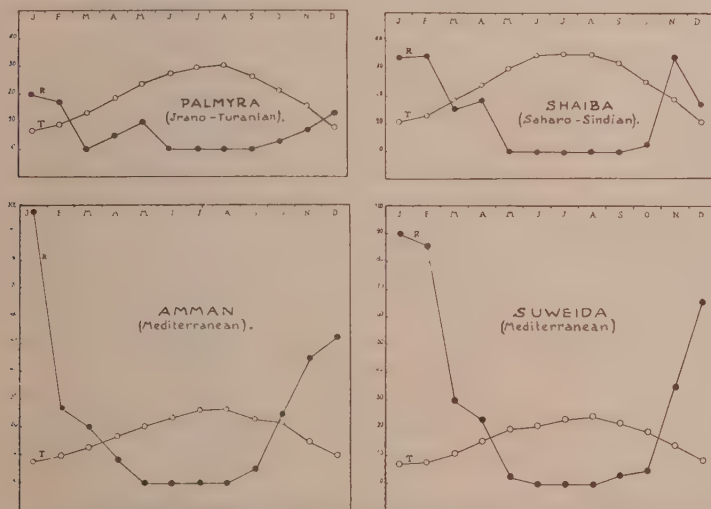


Figure: Hydrothermic curves of 4 distant stations.

R—monthly distribution of rainfall in mm.

T—mean monthly temperatures in °C.

Some striking points may be mentioned here in connection with the climatic conditions as as factor controlling plant distribution.

(1) Sudano-Deccanian plant communities penetrate into the Jordan Valley towards N as far as the 32nd parallel. In the interior of the Desert, however, these communities cease to advance northward before the 30th parallel is reached, in spite of the fact that in northerly latitudes there also exist a series of

MONTHLY DISTRIBUTION OF PRECIPITATIONS IN MM.

	S	O	N	D	J	F	M	A	M	J	J	A	Total	Years of record
Aleppo	1	3	36	48	55	80	28	40	9	—	—	—	300	3
Deir-e-Zor	—	2	14	25	42	17	9	10	1	—	—	—	120	4
Semnie	—	10	21	73	63	76	36	20	10	—	—	—	309	4
Damascus	2	9.6	29.4	37	50.1	28.9	5.9	12.7	4.1	0.4	—	—	180.1	7
Palmyra	—	3	7	13	20	17	—	5	10	—	—	—	75	5
Suweida	2.9	4.9	34.9	66	90.5	86.4	30.4	23.3	2.6	—	—	—	341.9	5
Rutba	1	—	18	11	18	21	2	1	9	—	—	—	91	4
Ramadi	—	3	36	22	22	25	15	5	2	—	—	—	130	4
Amman	5.3	24.1	45.1	51.1	98.5	27.1	20.5	8.4	—	—	—	—	280.1	4
Tafite	14.5	12.8	46.2	56.3	52.6	24.9	12.0	—	—	—	—	—	219.3	4
Petra	—	7.2	17.2	19.2	42.9	46.2	20.0	14	0.3	—	—	—	167	4
Ma'an	—	6.5	5.5	3.7	7.8	12.4	5.2	5	0.5	—	—	—	46.6	4
Shaiba	—	3	35	17	34	35	6	9	0.4	—	—	—	139.4	10

MEAN MONTHLY TEMPERATURE IN °C

	S	O	N	D	J	F	M	A	M	J	J	A	Absolute Min.	Max.
Aleppo	25.9	19.7	16.5	7.7	6.1	6.8	11.5	15.9	21.3	26.4	28.3	28.9	-6	+42
Deir-e-Zor	26.9	20.5	14.0	8.5	5.7	8.2	11.8	18.3	23.9	29.3	32.0	32.1	-8	+44
Damascus	24.9	19.7	15.1	9.4	7.2	8.4	12.3	17.0	21.3	25.4	25.4	26.9	—	+44
Palmyra	26.6	21.6	15.6	9.4	7.3	8.9	13.4	19.3	24.6	27.8	29.8	30.3	-8	+47
Suweida	22.6	19.3	14.1	9.0	6.9	7.3	11.3	15.0	19.9	20.9	23.3	24.5	—	+50
Shaiba	32.3	26.0	19.0	11.5	11.0	13.5	19.5	24.5	31.0	34.5	36.0	35.5	-7	+50
Ramadi	30.0	23.0	16.7	10.3	7.8	13.9	17.2	21.0	28.5	32.2	34.1	33.4	-7.8	+49.5
Rutba	28.4	21.7	14.8	8.6	6.9	13.0	15.0	19.7	25.0	28.0	30.8	30.9	-7.8	+45.5

habitats (Wadi Sirhan, Jauf, Sakaka etc.) which could well supply the edaphical requirements of these plants.

(2) Similarly the cultivated date palm, which is very abundant along the lower course of the Euphrates and Tigris ceases to be an economic factor along the same rivers north of the 34th parallel.

(3) An interesting fact is that the Mediterranean *Ficus carica* and *Olea europæa* cultivated in Soukhne (NE of Palmyra) appear altogether stemless and branching from the base, owing to the extreme temperature (-8°) to which these trees are here exposed.

(4) That the above mentioned figures cannot always explain vegetational circumstances may be demonstrated by the following instances. The annual measurable amount of the precipitations of Palmyra and its vicinity does not exceed 75 mm. It is, however, known that some mountain ranges in these districts are rather thickly covered with snow for 1-3 months, and that a considerable amount of melting snow annually irrigates the valley, in addition to the measurable quantity of rain.

(5) In the southern part of the Desert vegetation is confined to shallow depressions, grooves and furrows, where rain-water accumulates or runs over for some time. The occurrence of such habitats alone allows the development of vegetation in districts where annual precipitations do not exceed 50 mm. (Ma'an, southern end of the Dead Sea and apparently between Ma'an and 'Aqaba).

(6) Still more interesting in this connection is the fact that in the sandy localities of the desert, especially in the South, vegetation is much more abundant than in non-sandy places. It is a known fact that some trees and shrubs of the desert are confined chiefly to sand dunes (*Haloxylon persicum*, *Calligonum comosum*, *Retama Roetam*, some species of *Tamarix* etc.) Here they are mainly limited to the well-watered dune bases and valleys between dunes. That is the main reason why the Nefud of Northern Arabia is richer in vegetation than the Hamd.

(v) On the botanical exploration of the Syrian Desert

A good many of data on the general history of the exploration of the Syrian Desert is to be found in the works of HOGART (1904), GRANT (1937), LESCH (1930), FISCHER (1919) and others. This history begins at a very

early date, but in botany very little was done before the 18th century.

Of the earlier botanists who contributed much to the knowledge of the borderland of the Syrian Desert mention may be made of A. RUSSEL. During his stay in Aleppo in the first half of the 18th century he studied the flora of Aleppo and its environs. His brother continued these studies until 1771 and published their results in the "Natural History of Aleppo".

In the same century important investigations were made by a series of other notable botanists and collectors who visited in the main the adjacent countries of the Syrian Desert, and collected rich material, on which the Flora of BOISSIER is partly based. These men were MICHAUX (1782), LABEL-LARDIERE (1787), OLIVIER (1795) and BRUGUIERE (1795).

The 19th century was an epoch of much progress in the floristic investigation of the Near East. In connection with the Syrian Desert AUCHER-ÉLOY (1830-35) may be mentioned. He traversed parts of Egypt, Sinai and Palestine, from where he continued to Mt. Hermon and Damascus, to Aleppo, Baghdad and Persia. Of the other botanists who visited the Syrian Desert, or at least its marginal parts, and whose collections were of fundamental value to the Flora Orientalis, the following may be mentioned: ROTH (1837) visited Palestine, Arabia Petraea and the Lebanon; KOTSCHY (1842-1855) collected abundant material in the environs of Aleppo, northern Mesopotamia, Lebanon, Antilebanon, etc.; BOISSIER (1846), the meritorious author of the Flora Orientalis who traversed several countries of the Near East, visited only the western edge of the Syrian Desert (Aleppo, Antilebanon, Hermon, Damascus); BLANCHE (1847) made the first botanical trip to Palmyra and discovered there a good many plants reported in the Flora Orientalis; HAUSKNECHT (1865) travelling in Mesopotamia, Asia Minor and Armenia also collected plants in Aleppo; PAINE (1865) visited a big part of Mediterranean Transjordan; GAILLARDOT (1877) collected chiefly in Damascus and Aleppo.

In the year 1863/64 Canon H.B. TRISTRAM visited some parts of the area under review and published his Fauna and Flora of Palestine in the *Palestine Exploration Fund Quarterly* for 1884. Unfortunately the botanical part of his work includes many data which are incorrect. Twenty years later H.C. HART travelled across Southern Transjordan and published the results in 1891. HART's work affords an important contribution to the flora and phytogeography of Palestine and the Syrian Desert.

In the year 1886 G.E. POST of the American College in Beirut made his first trip to Transjordan and Hauran (1888). Four years later POST traversed twice the Antilebanon mountains and visited several localities in the Palmyrena. The botanical results of these journeys were published in the *Plantae Postianae*, Lausanne 1890-91, and full reports are given in a paper published in 1891. The collections and reports of POST have contributed much to the knowledge of the flora and vegetation of the interior Syrian Desert.

Among the botanists and collectors of the 20th century who participated in the botanical investigation of the Syrian Desert the following may be mentioned: J.E. DINSMORE who since 1911 has traversed Transjordan several times. His floristical observations were published in "The Jerusalem Cata-

logue" (1912) and in Post's Flora (1932-1933). A series of botanical journeys to Transjordan, Hauran, Golan and Hermon were carried out during the years 1904-1911 by A. AARONSOHN. The greater part of his botanical collections and observations was recently published by H. R. OPPENHEIMER (1931).

Extensive work in this connection has been done by J. BORNMUELLER in publishing a series of contributions to the knowledge of the Flora of some Near East countries during the years 1904-1928. Although BORNMUELLER only visited the borderland of the Syrian Desert his collections and floristic papers on the Near East flora are highly important for botanical studies of the Syrian Desert.

In the years 1909, 1910 F. NABELEK visited Transjordan, Hermon, Aleppo, the right bank of the Euphrates, etc. The results of his botanical journey published during 1923-1929 added much to the knowledge of the flora of this country, especially for southern Transjordan.

A considerable step forward was made by H. V. HANDEL-MAZZETTI in 1910 who traversed some parts of Mesopotamia, Kurdistan, Syria, etc. His papers (1912-14, 1914) are an indispensable source for all floristic and phytogeographical work on Mesopotamia and Kurdistan and partly also on the Syrian Desert.

Of the travellers and botanists mentioned there was apparently no one, except BLANCHE and POST¹, who penetrated deeply into the interior of the Syrian Desert. Only in the last decade attempts were made to cross the interior desert in various directions. As our present paper is based to a great extent on the geobotanical and floristical studies which have been carried out recently, we mention most of these expeditions here.

During the years 1925-1939, the author several times visited the eastern shores of the Dead Sea, either alone or together with Dr A. EIG.

In the year 1927 A. EIG, N. FEINBRUN and the author made geobotanical studies in Transjordan and advanced eastwards as far as Kasr Harani in the desert E of Amman and Khirbat Tmeire E of Gilead.

Two years later A. EIG and the author traversed Transjordan from Jericho all along the Hejas railway to Ma'an, Petra and the Gulf of 'Aqaba. This trip yielded exceptionally copious material, of which only a small part has been published.

In the year 1930 the author crossed the Desert through the Damascus-Palmyra-Deir-e-Zor line.

In the year 1931 the author traversed the borderland of the Syrian Desert between Damascus and Aleppo, and between Damascus and Jebel Druz. In the same year, as well as in 1932, R. GOMBAULT visited Jebel Amiri (SE of Aleppo) and published a plant list of this mountain (1933)².

¹ TH. STRAUSS also penetrated partly this Desert from the East (see BORNMUELLER (1905), *Plantae Straussianae. Beih. Bot. Ctrbl.* 19, Abt. II, p. 197).

² R. GOMBAULT, as may be seen from his papers (1934) made botanical excursions also in some other parts of the Syrian Desert (Jebel Druz, Deir-e-Zor, Palmyra, Abu Kemal etc.).

In the year 1932 A. EIG and the author made a geobotanical exploration of the eastern slopes and foot hills of the Antilebanon, as well as of Hauran and Jebel Druz.

In the same year J. THIEBAUT and R. GOMBAULT visited Jebel Tanf and published a list of plants of these environs (1932).

In the spring of 1933 A. EIG and the author, while on a geobotanical trip to Iraq, crossed the central part of the Syrian Desert along the Damascus-Baghdad road. In the same year we investigated another unknown part of this desert, namely the SE corner of the Desert (Basra-Ur and Basra-Sulbie). Returning from Iraq in the same spring we crossed the Northern Desert at a line passing Deir-e-Zor-Soukhne-Selemie-Hama.

In the summer of 1933 we crossed the desert again (together with N. FEINERUN), but in a more southerly line, namely between Amman-Rutba-Ramadi passing the northern edge of Wadi Sirhan and the Harrat-er-Rajil.

In the year 1934 Col. MEINERTZHAGEN collected plants in the environs of Rutba and Azraq. His collection was published by SAMUELSSON (1935).

In the same year G. SAMUELSSON, while on a botanical journey in Palestine and Syria, traversed the northern part of the Syrian Desert. Only a small part of the results of his journey have hitherto been published (1938).

In the spring of 1936 A. EIG, N. FEINERUN and the author carried out a second trip through the steppe and desert part of Transjordan from the Jordan river (n. Jericho) to the Gulf of 'Aqaba.

Of the explorers other than botanists who added so much to the botanical knowledge of the southern part of this Desert, the name of ALOIS MUSIL must be mentioned. This outstanding explorer of Arabia has observed and collected plants in all his long journeys through Arabia and the Syrian Desert, but unfortunately only part of his collection was published. In his works (1907, 1927, 1928), particularly in his "Arabia Deserta" one finds here and there short lists of plants, partly identified and published by VELENOVSKY (1921-22). Since a great part of Arabia Deserta have not been visited by a botanist, MUSIL's observations and collections must be considered as an important source for the plant geography of this region.

Besides MUSIL mention may be made in this connection of PHILBY (1922), CHEESMAN (1926), BLUNT (1881), DOUGHTY (1933), CARRUTHERS (1935), who quote in their works various plant names or even plant lists or other botanical data of the area under review.

SPECIAL PART :

THE PHYTOGEOGRAPHICAL ANALYSIS OF THE FLORA AND THE SUBDIVISION OF THE SYRIAN DESERT

The flora of the Syrian Desert is comparatively rich. No less than 2040 species have so far been encountered in this country. This number is certainly not complete, as there are rather large stretches in the southern part of the country still unexplored. On

the other hand there are a good many genera which are awaiting critical revision. Such monographic revisions will no doubt lead to the discovery of new species, as was the case with some recently revised genera: *Verbascum*, *Anthemis*, *Astragalus* and others. Nevertheless most probably these future discoveries will not, to many extent alter our conclusions on the phytogeographical relations and subdivision of the Syrian Desert.

This striking abundance in species for a subdesert country is not very astonishing when we consider the following facts: (1) The Syrian Desert is bordered on the west by a Mediterranean flora very rich in species. (2) The Syrian Desert within the limits dealt with here, is exceedingly rich in habitats due to its diverse orographical, geological and climatical conditions.

The Flora of the Syrian Desert is composed of at least five phytogeographical elements¹. These are: The Mediterranean, the Irano-Turanian, the Saharo-Sindian, the Eurosibero-Boreo-american and the Sudano-Deccanian. Whereas those parts of the flora belonging to the three first-mentioned elements are limited to a special territory of the country, the parts belonging to the last two do not occupy any special territory in the Syrian Desert. Besides these monoregional plant groups, there are numerous plants which belong phytogeographically to two or more regions. These are the bi-, tri- and pluriregional plant groups.

Before dealing with each group in detail, a short numerical view of the groups may be given here:

¹ Most of the phytogeographical terms applied in this chapter are explained in detail in the paper by EIG (1931) and ZOHARY (1935). For convenience, however, some of them are briefly explained here:

(1) Element. The flora and vegetation peculiar to a phytogeographical region constitute the element of that region.

(2) Phytogeographical territory. Countries situated on the limit of two or more regions necessarily consist of two or more phytogeographical territories, each belonging to a special region. The island of Cyprus for example constitutes only a single (Mediterranean) territory. Palestine is made up of three territories, as it represents the meeting-place of three phytogeographical regions.

(3) Enclaves are limited areas in a given region inhabited by a flora and vegetation of foreign regions.

(4) Bi-regional plants are plants naturally occurring in two regions having in both more or less similar ecological requirements. In the same sense do we understand the terms tri- and pluri-regional or polychorous plants.

MONOREGIONAL PLANT GROUPS

(1) Sub Mediterranean	88 species	
Omni Mediterranean	103	
East Mediterranean	215	
Sub East Mediterranean	76	
South Mediterranean	12	
North Mediterranean	26	
(Mediterranean)		Total 520 species
(2) Irano-Turanian group		
(incl. Sub Ir.-Tur.)	563 species	
Mauretano-Steppe—Irano-		
Turanian	25	
(Irano-Turanian)		Total 588 species
(3) Sub Saharo-Sindian	35 species	
Omni Saharo-Sindian	82	
Middle Saharo-Sindian	117	
East Saharo-Sindian	21	
West Saharo-Sindian	38	
(Saharo-Sindian)		Total 239 species
(4) Eurosibero-Boreoamerican		Total 10 species
(5) Sudano-Deccanian		Total 24 species

BIREGIONAL PLANT GROUPS

(1) Mediterrano—Irano-Turanian		
(incl. Sub Medit.—Ir.-Tur.)	227 species	
(2) East Mediterrano—Irano-		
Turanian	122	
(3) North Mediterrano—Irano		
Turanian	15	
(4) South Mediterrano—Irano-		
Turanian	10	
(5) Mediterrano—Saharo-Sindian	6	
(6) Mediterrano—Eurosiberian	22	
(7) Irano-Turano—Saharo-Sindian	35	
(8) Saharo-Sindo—Sudano-		
Deccanian	20	
		Total 457 species

TRI- AND PLURI-REGIONAL PLANT GROUPS

(1) Med.—Ir.-Tur.—Saharo-Sindian	11 species
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(2) Eurosib.-Boreoam.—Med.—	
Ir.-Tur.	83
(3) Tropical	15
(4) Borealo—Tropical	60
(5) Med.—Tropical	5
(6) Sud.-Decc.—Tropical	1
(7) Med.—Saharo-Sindo—Tropical	2
(8) Med.—Ir.-Tur.—Tropical	14
(9) Med.—Ir.-Tur.—Saharo-	
Sindo—Tropical	11
Total 202 species	

(i) *The monoregional plant groups (elements)*

(1) *The Mediterranean element*

(a) *Subdivision and affinities*

This element is represented in the Syrian Desert by 520 species, which are 37,5% of the total number of monoregional species. This is a very high proportion, considering the fact that the Mediterranean territory of the Syrian Desert occupies only a small fraction of the Syrian Desert as compared with the Irano-Turanian and the Saharo-Sindian territories. It may be explained by the comparative richness of species characteristic of the Mediterranean region. For example, in the central part of the Desert (Irano-Turanian territory), over a distance of about 900 km. we found not more than 175 species, whereas in the Mediterranean part, in the immediate environs of Amman, we found over 200 species on a surface not exceeding 4 sq. km.

Of these 520 species, 291 belong to the East Mediterranean subregion, a number which brings out the East Mediterranean character of the flora. On the other hand, the 191 species which belong to the omni- and sub-Mediterranean group show, that in comparison with the Irano-Turanian or even with the Saharo-Sindian region, the Mediterranean region is a natural and floristically more or less homogeneous region.

As for the vegetational significance of Mediterranean plants, it should be remarked that out of the total number of species belonging to this element, over a hundred occupy secondary habitats (hemerophytes). On the other hand a large number of phyto-sociologically important plants of the Syrian Desert be-

long to the East Mediterranean subregion, as for instance *Quercus calliprinos*, *Qu. ithaburensis*, *Qu. infectoria*, *Pistacia palaestina*, *Crataegus Azarolus*, *Arbutus Andrachne*, *Rhamnus palaestina*, *Pyrus syriaca*, *Origanum syriacum*, *Thymbra spicata*, *Salvia triloba*, *Poterium spinosum*, *Rubia Olivieri*, *Varthemia iphionoides* and many others.

In addition, a series of East Mediterranean plants was found here which also occurs in Syria and the Lebanon, but is lacking in Cisjordanian Palestine, as for instance: *Lecokia cretica*, *Vitis orientalis*, *Scutellaria Sibthorpii*, *Scrophularia libanotica*, *Prangos asperula*, *Opopanax orientalis* and others. This fact shows that the flora of the Mediterranean territory is more closely related to that of Syria and the Lebanon than to that of western Palestine.

(b) *The Mediterranean territory* (see map)

As has already been pointed out, the Mediterranean element occupies a special territory in the Syrian Desert, or, to be more accurate, two territories: one in Transjordan, the other in the Jebel Druz. For the delimitation of these territories we made use of data scattered in botanical and non-botanical literature. We make especial mention of the following authorities: TRISTRAM (1873), SCHUMACHER (1888), POST (1888), AARONSOHN (OPPENHEIMER 1930), MUSIL (1927). For the most part, however, we relied on the work of EIG (1931, 1938) and on our own observations.

(1) *The Transjordanian territory.* The most southerly point of this territory is the district of Petra, e.g. the Ein-Musa—Petra—Jebel Harun line. This is the southern terminus of Mediterranean vegetation in Asia. North of Petra the Mediterranean vegetation occupies a narrow longitudinal strip in Edom (including the higher zones of the mountain range situated between Petra; Shobek, 1330 m.; Tafiie, 1005 m.), Moab (Kerak, 1000 m.; Madaba, 785 m.), Amman, Gilead and Golan. This strip, although especially in Moab frequently interrupted by latitudinal wadies emptying into the Jordan Valley and by lowlands now bearing a non-Mediterranean vegetation, must nevertheless be roughly considered a Mediterranean belt. Its average breadth is about 15 km. North of Wadi Sirr (SW of Amman) the strip broadens abruptly, comprising a great part of Amman, nearly

the entire Gilead, and the western part of the Golan, where it meets the Mediterranean territory of Upper Galilee and of the Lebanon (see map). Within this belt, three parts can be distinguished: (a) The southern part (Edom), situated between Ein Musa and Wadi Hasa; this part is comparatively rich in Mediterranean forest stands or remnants of such stands. (b) The middle part (Moab). Here we find only vestiges of Mediterranean vegetation. (c) The northern part, comprising the districts of Amman, Gilead and Golan; it is the centre of Mediterranean vegetation in this territory, and is the part richest in wood and maquis associations.

(2) The enclave of Jebel Druz comprises the higher ranges of Jebel Druz and is separated from the Mediterranean Golan by the Irano-Turanian Bashan (Hauran Plain). The Mediterranean character of this enclave is particularly striking on account of the occurrence of *Quercus calliprinos* forests. These forests we studied in Jebel Jina, in the vicinity of Suweida, el-Kafr and Suleim; we also possess data on the flora of Jebel Quleib.

The limits of these territories, are indicated in the accompanying map only tentatively, our data being too fragmentary for accurate delimitation. In this connection two points should be borne in mind: Firstly, the Mediterranean vegetation here has been constantly destroyed for thousands of years by the inhabitants of the adjacent steppe and desert. Certain parts of this belt, today either bare or covered by non-Mediterranean vegetation, might thus have been occupied in the past by a typical Mediterranean vegetation. Secondly, owing to the phytogeographical position of this belt (at the terminus of the Mediterranean region) the process of natural regeneration of the affected vegetation is greatly retarded or even entirely prevented, so that it is very difficult to establish accurate boundaries for the Mediterranean climax territory.

Besides the Golan and Jebel Druz there is no other Mediterranean territory in the Syrian part of this area. In Syria the western limit of the Syrian Desert is at the same time also the western limit of the Irano-Turanian territory. It is true that on the Homs-Aleppo line and especially in the environs of Aleppo a large number of Mediterranean plants occur, but these are mostly of lower phytogeographical importance (hemerophytes and hydrophytes).

(c) *The vegetation of the Mediterranean territory*¹

The Mediterranean territory as a whole constitutes an area of arboreal climax associations. In the present day, however, these associations are considerably affected by man, so that large tracts of this territory are occupied by hemerophytes (cultures, segetal and ruderal plants).

Of the forests, maquis, and their degradation stages, the following may be mentioned:

(1) *Pinus halepensis* — *Hypericum serpyllifolium* association (Erg, 1938). At present this forest association occurs only in Gilead and Amman, the most developed stands occurring in the environs of Jarash. In its composition, it is quite identical with the same association found on Mt. Carmel. There is some evidence that this forest type must have been abundant in the past, but owing to abuse by man and also because *P. halepensis* lacks the power of regeneration, these forests have disappeared from wide tracts. (Plate II A).

(2) *Quercetum calliprini*. This is a very striking forest type. *Quercus calliprinos* is almost the only tree here. It is met with in Jebel Druz (North of Suweida) at an altitude of 1250-1300 m. In appearance it recalls a park-forest and resembles *Pistacietum atlanticae* found in the Syrian Desert. It is the same *Quercus* species common as a leading plant in some maquis associations, but here it has a tree habit. Between the trees a herbaceous layer develops consisting of Mediterranean grasses and herbs. Since we have not found any second example of such forests in the Syrian Desert and in the adjacent countries, we believe that this association is secondarily formed by the thinning out of the *Quercus calliprinos* — *Pistacia palaestina* association (Erg, 1938), one of the common maquis types in the East Mediterranean subregion. This is proved, firstly, by the fact that stunted specimens of *Crataegus Azarolus*, elsewhere a frequent associate of the last named association, occasionally occur in the neighbourhood; secondly by the ability of *Quercus calliprinos*, as of other maquis shrubs, to develop into big trees when growing in thinned-out groves and protected from destruction.

¹ The plant communities of the central, northern and eastern parts of the Syrian Desert, mentioned in this paper were studied in the years 1931-1933 by the late Dr Erg and the author.

(3) *Quercetum ithaburensis*. This association was thoroughly studied in western Palestine by EIG (1933). It is found in Gilead and western Golan and it was already observed there by SCHUMACHER (1888), TRISTRAM (1873), and others. According to descriptions by reliable authorities, this forest type was most abundant in Transjordan, where it is also encountered in non-typical Mediterranean conditions. In the lower regions of the Golan mountains facing the Jordan Valley, for example, it touches the Irano-Turanian *Zizyphetum Loti* and *Pistacietum atlanticae*.

(4) In Jebel Druz we also found remnants of a mountain forest type, the composition of which is not quite clear to us. The few shrubby individuals we collected of this type are: *Crataegus monogyna*, *Acer microphylla*, *Cotoneaster nummularia*. Adding to this list *Quercus Cerris*, found in this environment by POST, as well as other plants reported to occur in these mountains we may assume the existence of a *Quercetum Cerridis* remnant here, somewhat similar in composition to that found in some higher ranges of Syria and the Lebanon.

(5) Another arboreal community is that of *Juniperus phoenicea*, well developed in the Mediterranean part of Edom. We have met this community twice in the vicinity of Petra, but there are reliable records of its occurrence in other places in this district. Phytogeographically, it is highly interesting that *Juniperus phoenicea*, a rather eu-Mediterranean species is altogether lacking in Syria and in western Palestine, and occurs just here in the southernmost point and terminus of the Mediterranean region in closest contact with Irano-Turanian plant communities. Its occurrence in the Sinai peninsula (Maghara, Jelleg, etc.) is likewise very surprising (ZOHARY, 1935).

In this connection we may mention that in the environs of Petra which belong to the Mediterranean territory we encountered a series of plants which must be regarded as relics of a special type of Mediterranean vegetation. These are *Hedera Helix*, *Rubia tinctoria*, *Daphne linearifolia* (endemic), *Colutea haleppica*, *Prunus prostrata*, etc.

Whereas the forest cover constitutes actually only a small proportion of the Mediterranean territory, the maquis and its various degradation stages are much commoner. Some brief re-

marks on these associations based upon our own observation may be given here.

(6) *Quercus calliprinos* — *Pistacia palaestina* association (EIG, 1938) is a type of maquis encountered most frequently in the East Mediterranean countries. In Transjordan we encountered it on the western slopes of the Amman mountains, in the interior of Gilead, and in some parts of the Golan mountains. It seems to occur also in Edom.

(7) *Quercus calliprinos*—*Crataegus sinaica* association. This is a special type of maquis encountered only once in Jebel Druz. It is composed of *Quercus calliprinos*, *Crataegus sinaica*, *Crataegus Azarolus*, *Prunus Amygdalus*, *Pyrus syriaca* and some annual or perennial non-typical Mediterranean and Irano-Turanian grasses and herbs. None of the common maquis undershrubs are to be found here. It is highly probable that the density and composition of this maquis type are a result of the interference of man. The peculiarity of this association lies, however, in the occurrence of *Crataegus sinaica* as a leading plant. This tree was hitherto known only in the Irano-Turanian territory of the Sinai mountains and in Persia. (Plate II B).

Of the degradation stages of maquis the following associations may be mentioned:

(8) *Poterietum spinosi*. This is the commonest dwarf shrub association of the *Poterion spinosi* (EIG, 1938) of the East Mediterranean subregion. It occurs in several countries and we have observed it in Golan, Amman and Gilead.

(9) In the Mediterraneo—Irano-Turanian borderland a special type of *Poterietum* appears—*Poterietum spinosi orientale*, so designated by EIG (m. sc.) because it includes many Irano-Turanian species which never occur in the eu-Mediterranean types. We observed this type near the Homs-Aleppo highway, near Amman and on the eastern slopes of Mt. Hermon.

(10) *Thymetum capitati* is rather rare in our district.

(11) *Varthemietum iphionoides*. A well distinguished association confined to rocky habitats (EIG, m. sc.).

(12) We did not notice any of the Garigue associations in our explorations. We believe, however, that these associations must be represented since several of their main species are not uncommon here.

We have cited here only the most striking plant communities. Most of them were studied and named by EIG and will be published at a later date.

(2) *The Irano-Turanian element*

(a) *Subdivision and affinities*

This is the most important constituent of the Syrian Desert flora. It comprises 563 species, i.e. about 43% of the total of monoregional species.

In attempting to give a more detailed phytogeographical analysis of the Irano-Turanian element, we must mention that so far, it is not quite certain whether the group of countries situated between Turkestan and the Sino-Japanese region belong to the Irano-Turanian region, or whether they constitute a separate independent region. A second question concerning this region is how to subdivide it into subregional units (EIG, 1931). As is well known, this region is rather heterogeneous in its flora and vegetation, especially if we are to include the countries of Central Asia, so that omni-Irano-Turanian plants do not exist at all or are very limited. According to a paper by POPOV (1931) there is some reason to retain the Irano-Turanian region within the limits accepted by GRISEBACH (1884), i.e. to include the Central Asian part also. If we accept this view we have for the time being to distinguish, together with EIG (1931), and partly also with POPOV (1931), GAJEWSKY (1931) and BOISSIER the following subregions¹: the Mesopotamian, the Iranian, the Aralo-Caspian, the Armeno-Anatolian, the Sarmatic, the Central Asian and the Mongolian.

These subdivisions are quoted with great reserve since our knowledge of this region is at present very limited, even though many papers dealing with the flora and vegetation of some Irano-Turanian countries have recently been published by Russian botanists. We could not, therefore, subdivide the Irano-Turanian element of the Syrian Desert into subelements, as has been done for the Mediterranean and Saharo-Sindian elements. We wish, however, to emphasise, two points in this regard.

¹ It is, however, questionable whether these subdivisions can be regarded as subregions.

(1) The Irano-Turanian plants of the Syrian Desert mostly belong to the Armeno-Anatolian and the Mesopotamian subelements. The Mesopotamian subregion comprises a part of the Syrian Desert and the greatest part of Mesopotamia. It is limited in the N by the Taurus ranges, in the NE by the Kurdistan mountains and in the E by the Zagros mountains and Luristan. In the W it is limited by the Mediterranean mountains of Transjordan, by the Hermon and Antilebanon and in NW by the mountain groups of Jebel Arbain and Jebel Ala (N.Syria). According to its geographical position this subregion is to some extent isolated from other subregions, and this no doubt accounts for the numerous endemics peculiar to it. The northern part of this subregion constitutes even an important centre of endemic species belonging to genera which are characteristic of the Irano-Turanian region. These are: *Astragalus*, *Onobrychis* (non-tragacanthic), *Verbascum*, *Salvia*, *Phlomis*, *Ferula*, *Teucrium*, *Cousinia*, *Asphodeline*, *Allium*, and others.

(2) Within the Irano-Turanian element we have also included 25 species belonging to a group designated by ERG (1931) as Mauretano-steppe—Irano-Turanian. These species occur in some countries of the Irano-Turanian region proper, as well as in the "Hauts Plateaux" of North Africa. This plateau is situated between the Mediterranean and Saharo-Sindian territories of the North-African countries, and is predominated by a steppe vegetation resembling certain territories of the Irano-Turanian region in physiognomy and partly in composition too. Further investigation may show that some plants designated in this paper as Saharo-Sindian—Irano-Turanian also belong to the Mauretano-steppe—Irano-Turanian group. The plants of this group, though numerically insignificant, are very important vegetationally in the Syrian Desert, in other Irano-Turanian countries, and no less in the North-African steppe zone. Among them are: *Pistacia atlantica* (the leading species of the *Pistacietum atlanticae*), *Rhus tripartita*, *Zizyphus Lotus*, *Haloxylon articulatum*, *Anabasis articulata*, *Artemisia Herba alba*, *Achillea Santolina*, *Noea mucronata* and others. It is important to realise that most of these species are phytosociologically of higher rank, being leading species of associations which cover thousands of square kilometres in the Syrian Desert. Hence we may conclude that the North-African steppe-zone (Hauts Plateaux) also forms a portion

of the Irano-Turanian region. This opinion is already held by REICHERT (1937) from a lichenogeographical standpoint. The latter even proposes to designate the region not "Irano-Turanian", but "Mauretano-Turanian".

(b) *The Irano-Turanian territory*

The delimitation of this territory is one of the most difficult tasks attempted in our present investigation, particularly its delimitation from the Saharo-Sindian territory. This is due to the fact that this border has no orographical features which may serve as a natural barrier against the intermigration and interchanging of these two floras. Thus it is only the climatic factor in this case, which determines the boundary between the closely related Saharo-Sindian and Irano-Turanian territories. Such a boundary can hardly be expressed by a mere line as we have done in this paper (see map).

Let us begin from the SW side of the country. This territory encircles the Mediterranean territory of Transjordan on the West, South and East, occupying there a more or less narrow belt between the Saharo-Sindian and Mediterranean territories. This belt begins on the western slope of the Golan mountains, includes the adjacent part of the Upper Jordan Valley, gradually narrows towards the South, and dwindles on the western slopes of the southern Transjordan mountains. In some places it is interrupted, but on the whole it can easily be traced. In the South the belt curves, circling around the Southern edge of the Mediterranean territory (Jebel Harun-Wadi Musa) and reaching its southernmost point approximately 40 km. S of Ma'an. From here it continues northwards on the eastern side of the Transjordanian mountains, so that its eastern border coincides roughly with the Ma'an-Qutrani railway line. From Qutrani the Irano-Turanian belt widens considerably towards the East its eastern borderline passing through Kasr Azraq, the upper course of Wadi Rajil, Harrat er Rajil, and the southern environs of Rutba. From here it passes NE to Hit, on the right bank of the Euphrates. The western borderline of this belt is formed in Transjordan by the eastern limit of the Mediterranean territory. In the northern Golan this line turns a little westwards passing the eastern slopes of the Hermon, Antilebanon, and the vicinity of the Homs-Hama-Aleppo road. The Irano-Turanian territory of the Syrian

Desert, thus, occupies the whole northern part of the Desert and an U-shaped strip encircling the Mediterranean territory of Transjordan. The Jebel Druz forms a Mediterranean enclave within this Irano-Turanian territory.

These lines are here drawn tentatively, in spite of comparatively abundant data. Future investigation, no doubt, will correct some points on these lines, especially in the Iraqi part of the Desert.

The following question arose in determining the boundary lines between the Irano-Turanian and Saharo-Sindian territories. Does the Irano-Turanian territory coincide with the steppe area and the Saharo-Sindian territory with the desert area of the country? In other words: Supposing we were able to distinguish easily between steppe and desert, could we use these characters in drawing a line between the Saharo-Sindian and the Irano-Turanian territories? The problems of steppe and desert have been discussed in detail by RIKLI-SCHROETER (1912), GRADMAN (1934), REGEL (1932), and many others. These authors have pointed out a series of distinguishing characters between steppe and desert, as for instance, the degree of covering of the vegetation, amount and distribution of annual precipitation, soil properties, agricultural possibilities, etc. Since all these characters do not express phytogeographical peculiarities of the flora, they can only exceptionally be applied in phytogeographical subdivisions. The Irano-Turanian territory of the Syrian Desert can thus by no means be identical with the steppe part of this country, as the Saharo-Sindian territory cannot be considered the only desert part of our area. Accordingly, we also have included within the Irano-Turanian territory some extremely desert tracts of the Hamd as well as wide stretches between Amman and Azraq, Deir-e-Zor and Selemie, because their flora belongs phytogeographically to the Irano-Turanian element.

(c) *The vegetation of the Irano-Turanian territory*¹

A closer examination of the vegetation of this territory reveals a series of well-distinguished plant communities each conditioned by special habitats. These habitats are not always easily distinguishable at first sight, since in extreme conditions

¹ See footnote 1 on p. 66 of this paper.

the habitat is also largely or even chiefly affected by micro-ecological factors, which can be discerned with difficulty.

In the following we mention some of the most prominent plant communities encountered in the Irano-Turanian territory.

(1) *Pistacietum atlanticae*. The most important arboreal plant association of the Syrian Desert. Hitherto has not been observed in this country, since *P. atlantica* was unknown in Asia.¹ The association of *P. atlantica* is, as is well known, one of the characteristic plant communities of the Mauretano-steppe district of North Africa. Its distribution area extends from the Canary Islands, through Morocco till Tripolitania. In Egypt, *Pistacia atlantica*, as well as other typical steppe plants of N. Africa, are lacking altogether, since, owing to orographical and climatical factors, the Saharo-Sindian territory closely approaches the Mediterranean Sea without allowing room for Irano-Turanian vegetation. On Asiatic territory we encounter *Pistacia* again, at first in the Sinai Peninsula, then in Petra and its vicinity (solitary, but well developed trees). Further north we found stands and remnants of *Pistacia* forests in the Jordan Valley and on the mountain slopes facing this Valley. We encountered well developed stands in the environs of Khirbet Tmeiri in eastern Gilead. In the vicinity of Kasr Amra (near Wadi el Butm) MUSIL (1927) observed a stand of *Pistacia* which was no doubt *P. atlantica*. We searched for vestiges of natural climax vegetation in the extensively cultivated Bashan for a considerable time, and finally found there stunted specimens of this *Pistacia*. Further north it is to be found at the foot of Jebel Druz (Suleim). We also received reliable information concerning the occurrence of stands of this *Pistacia* on the eastern slopes and foot-hill region of the Antilebanon (Jebel Butm, Aarsal, Ein Tineh, etc.). It is very abundant in the Palmyrenian mountain chains and in the Jebel Abiad plateau. Here we studied this association in the Jebel Muqeibra and Jebel Waar about 70 km. NW of Soukhne. MUSIL (1928) also mentions extensive *Pistacia* stands from the Abu Rejmen mountains. Outside the area under review forests of *P. atlantica* are abundant in Jebel Abd-el-Aziz and in Jebel Sindjar (in the Syrian-Iraqian borderline), but the specimens we collected

¹ The records of POST (1932-33), BOISSIER (1867-88) and others on *P. mutica* from Syria and Palestine probably refer to *P. atlantica*.

in the last two localities belong to a form intermediate between *P. atlantica* and *P. mutica*. These are apparently the most north-eastern stations of *P. atlantica*. In the adjacent Kurdistan mountains this species is replaced by its close relative, *P. mutica*.

In its physiognomy this forest type may be classed as a park forest. The trees are scattered and the spaces in between are occupied by herbaceous plants, mainly Irano-Turanian. Its composition is only little known to us. Observations in Jebel Mu-keibra show that this association also includes a few other shrubs, such as *Rhamnus palaestina*, *Prunus microcarpa* (?) and some dwarf shrubs, such as *Artemisia Herba alba*, *Noea mucronata*, *Haloxylon articulata*, etc. We found a somewhat similar composition in the Jebel Abd-el-Aziz. *Pistacietum atlanticae* is thus one of the deciduous forest associations common and characteristic of more favourable conditions in the Irano-Turanian region.¹ (Plate II C).

We have treated the distribution of this forest type in greater detail because it is unknown in Asia and because its main species is of economic significance (ZOHARY, 1938).

(2) *Zizyphetum Loti*. This, too, is a highly interesting association, but considerably rarer than *P. atlantica*. In its general distribution, *Z. Lotus* is quite similar to *P. atlantica*, but, unlike the latter, *Z. Lotus* is a thermophilous plant, confined in Palestine and Syria to plains, valleys and depressions which shelter it against low temperatures. Its most suitable habitats are deep alluvial soils containing sufficient moisture. In the Irano-Turanian territory of the Syrian Desert, *Zizyphetum Loti* is limited to the Upper Jordan Valley and to the mountain slopes facing it. Here, at altitudes ranging from 200 m. above to 200 m. below sea-level it is the most characteristic plant association. Further north we have encountered stands of *Z. Lotus* in the Hamma plain (between Hamma and Selemie) and in the Antiochia plain.

¹ Dealing with the Irano-Turanian region, EIG (1931) states that the deciduous forest types occupying the western and northern slopes of the Kurdistan and Persian mountains may be considered as Mediterranean enclaves. In the year 1933, however, while carrying out geobotanical studies in the forests of Kurdistan, EIG changes his opinion on this matter and considered these forests as a special type of Irano-Turanian mountain vegetation. Taking the composition of these forests into consideration, there is no doubt that this forest type suggests some Eurosiberian rather than Mediterranean wood communities.

(3) The association of *Rhus tripartita* may also be mentioned here. This plant shows a general distribution similar to that of the two above-mentioned plants, but is very rare and does not play a marked role in the vegetation of the Syrian Desert.

Of the non-arboreal steppe communities the following are the most important.

(4) *Artemisietum Herbae albae* (EIG, 1938). It is the most important association of the Syrian Desert because of its wide distribution and because it truly expresses Irano-Turanian conditions. It is very common and is characteristic of the vast undulating plains, but also ascends the slopes of the Antilebanon and Hermon up to a height of 1800-2000 m. It prefers the deep, greyish white, somewhat compact steppe soil and completely avoids saline or rocky soils. It is the first to penetrate into Mediterranean arboreal communities of the borderland affected by man and to make up the undergrowth in these cleared woods (Petra, Antilebanon, etc.). (Plate III A).

Artemisietum Herbae albae usually appears in two aspects: the spring aspect is generally very rich in annuals and is often characterised by *Poa sinaica*. The summer aspect is constituted by the tardily flowering *Artemisia* and other, chiefly chenopodiaceous perennials. Sometimes the *Artemisietum* appears only in its spring aspect and the leading species is lacking altogether.

(5) *Haloxylonetum articulati* (EIG, l.c.). This, too, is a very common association (perhaps an alliance of associations) in this territory. It is very characteristic of the stony and gravelly soils of the Hamd. Very often *Haloxylon* is also a constant associate of *Artemisietum*. Being exceptionally resistant to drought, it penetrates also into the Saharo-Sindian territory. (Plate III B).

(6) *Anabasetum articulatae*. Widely distributed, but less common than the latter. Often replaces *Artemisietum* in depressions and in somewhat wet places. Occurs here also in irrigated fields as a weed. It is by no means a true halophyte, although able to endure saline soils to some extent.

(7) *Noeetum mucronatae* (EIG, l.c.). Rather uncommon and limited to the western part of the territory. The ecological requirements of this association are insufficiently known to us. On one hand, *Noea* is encountered as a constant component or even as a leading species of certain alpine tragacanthic commun-

ities of the Hermon, Jebel Druz, Lebanon and Antilebanon. On the other, *Noea* is met with in sandy fields south of Ma'an, forming there, together with *Zilla spinosa*, a plant community which, from the point of view of composition and ecology, seems to be of Saharo-Sindian nature.

(8) *Salsolietum villosae* (EIG, l.c.), like *Haloxylonetum* is an association of extremely subdesert conditions, but usually avoids stony habitats. It is not very common in the Desert, but *Salsola* also occurs here and there as an associate of other plant communities.

The following associations are of lower value:

(9) *Leonticetum minoris*. We encountered this rather rare association on hills in central parts of the country. It is no doubt only a variation of *Artemisietum*.

(10) *Feruletum Blanchei*. Similar to the *Leonticetum*.

(11) *Amygdaletum spartioides*. We encountered this association only once on the banks of Wadi Muhammadi.

(12) *Capparidetum parviflorae*. Between Wadi Muhammadi and Ramadi. Not sufficiently known to us.

(13) The association of *Cleome glauca* — *Celsia lanceolata* is found in the vicinity of Deir-e-Zor and eastward; it is confined strictly to gypseous soils.

(14) *Asphodelus microcarpa* — *Gundelia Tournefortii* forms a striking association which we met in the environs of Hama-Selemie. No doubt one of the associations characteristic of Mediterranean—Irano-Turanian transition areas.

(15) Mention may also be made of the occurrence of a tragacanthic community in the summits of Jebel Druz. We observed it on the top of Jebel Jina, 1800 m., but could not study it sufficiently. The predominant plants here are *Noea mucronata*, *Ononis leiosperma*, *Astragalus supranubius*.

(16) One of the most important segetal associations is *Phlomis pungens* — *Centaurea myriocephala*. Its main centre of distribution seems to be the Bashan and the Homs plain, both basaltic and very fertile. From here the association penetrates partly into the Esdraelon plain and the Golan. In this connection it is important to note that the majority of the plants composing this association were not found in our district in primary habitats, though some of them occupy very limited areas or are even endemic here.

On the other hand we observed a series of species, which in the Mediterranean territory of the Syrian Desert, Syria, or Western Palestine appear as segetal plants, while growing in natural associations within the Irano-Turanian territory. Instances of these are: *Bellevalia longipes*, *Chorispora syriaca*, *Malcolmia crenulata*, *Malabaila sekakul*, *Leontice* *Leontopetalum*, *Filago spathulata*, *Gundelia Tournefortii*, etc. The problem of the origin of segetal plants of the East Mediterranean countries merits much attention and cannot be solved or even discussed in detail before the flora and vegetation of the Irano-Turanian countries are much better known than they are at present, as the Irano-Turanian flora presents the main source of this group of segetal plants.

Of the other plant communities mention should be made of some hydrophytic and halophytic associations. It must, however, be emphasised that some of these associations occur also in the Mediterranean, and even in the Saharo-Sindian territories.

(17) *Prosopidetum Stephanianae*. Is very abundant in the inundation area of the Euphrates and other water courses. It is confined to deep, heavy, and more or less moist soils. It sometimes also occurs in saline marshes.

(18) *Populetum euphraticae* (EIG, l.c.). Is common along the banks of the Jordan and other water courses emptying into the Jordan Valley, and also along the Euphrates. Of the chief components of this association we mention here *Populus euphratica*, *Salix Salsaf*, *S. acmophylla*, *Tamarix Jordanis*, etc. This gallery forest is very striking, since it is situated in the midst of a desert landscape.

Besides these two associations we also noticed associations of *Arundo Donax*, *Phragmites communis*, *Typha angustata*, *Nerium Oleander*, *Rubus sanctus*, and others encountered here and there along the water courses.

Finally some of the halophytic communities may be mentioned. These are confined mostly to the so-called sabkhas, of which there are at least three kinds within the district: (a) Natural sabkhas situated in the immediate vicinity of salt lakes and periodically inundated by them; for example, the sabkhas of the Dead Sea shores. (b) Natural sabkhas arising in flat depressions by the rapid evaporation of rain-water accumulated in the rainy season. These are to be found in several parts of the country. (c) Man-made sabkhas found near sources of irrigation (in the

vicinity of the southern course of the Euphrates) and caused by bad methods of irrigation.

The following halophytic plant associations were observed: *Arthrocnemum glaucum*-*Tamarix mannifera* (?), *Salsoletum tetrandrae*, *Tamaricetum tetragynae*, *Nitrarietum retusae*, *Atriplicetum Halimi*, *Juncetum maritimi*, *Aeluropetum repentis*, *Suaedetum monoicae*, etc. (Plate IV B).

(3) *The Saharo-Sindian element*

(a) *Subdivision and affinities*

This element is represented here by 239 species, of which the following geographical groups may be distinguished: (a) Omni and Sub Saharo-Sindian group — 63 species — about 26%; (b) Middle Saharo-Sindian group — 117 species — about 49%; (c) East Saharo-Sindian group — 21 species — about 9%; (d) West Saharo-Sindian group — 38 species — about 16%.

It is clear that the total figures mentioned here are far from definite, since, as has already been pointed out, the Saharo-Sindian part of the Syrian Desert is the least investigated. Future investigations may increase the known number of species considerably, but it is doubtful whether the numerical proportions of these groups will alter.

The occurrence of such a high percentage of plants belonging to the Middle Saharo-Sindian subregion in comparison to that of the East and West Saharo-Sindian group emphasises the fact that the floristical relations of our territory to Sinai and Egypt are much closer than to Persia, Beluchistan and Sind. From the vegetational point of view, however, the East and Middle Saharo-Sindian subelements are here of nearly equal importance. Of the Middle Saharo-Sindian species most important are phytosociologically: *Zygophyllum dumosum*, *Chenolea arabica*, *Tamarix mannifera*, *Atriplex leucocladum*, *Suaeda asphaltica*, *Artemisia judaica*, *Ephedra Althe*, *Artemisia monosperma*, *Fagonia* ssp., *Aristida Forskahlei*, *Astragalus spinosus*, *Helianthemum ellipticum*, and others. On the other hand there are here several East Saharo-Sindian species which are leading plants of highly characteristic communities. These are, for instance, *Haloxylon salicornicum*, *Heliotropium persicum*, *Rhanterium epapposum*, *Zizyphus nummularia*, but mostly confined to the eastern part of the Saharo-Sindian territory. The plants belonging to the Omni and

Sub Saharo-Sindian group are here vegetationally almost inconspicuous. Unlike this group, there are a few other plants of the West Saharo-Sindian group which reach their eastern limit of distribution here or in southern Persia and play an important role in the local vegetation. These are: *Salsola tetrandra*, *Scrophularia hypericifolia*, *Nitraria retusa*, *Heliotropium luteum*, *Helianthemum kahiricum*.

(b) *The Saharo-Sindian territory*

This Territory occupies the greatest part (the southern half) of the Syrian Desert. In the Jordan Valley it occupies a strip situated between the Irano-Turanian belt and the frontier. East of the Transjordanian mountains the western and northern borderlines of this territory are formed by the eastern and southern limits of the Irano-Turanian territory (see map).

(c) *The vegetation of the Saharo-Sindian territory*

We have studied the vegetation of this territory in three parts only: (1) in the Ma'an-Aqaba district, (2) in the Jordan Valley, (3) in the environs of Basra-Sulbie-Ur (southern Mesopotamia). For the central part of this territory (namely for the Wadian, Hamd, and Wadi Sirhan) we possess only scant records of which those made by MUSIL (1927), are the most important.

Despite the poverty of the flora, this territory exhibits a comparatively rich series of plant communities well-distinguished from those of the Irano-Turanian territory. To some extent, this is due to the occurrence of several habitats only poorly or not at all represented in the Irano-Turanian territory. The sandy habitats especially, play here a role of major importance. In most cases the sands occurring in this territory consist of weathered Nubian sandstone, but apparently there are also sands transported from the Nefud.

It must be noted that the plant communities enumerated here constitute only a fraction of the vegetation of this territory, since large tracts still await exploration.

(i) *Haloxylonetum salicornici* (EIG, l.c.). This is probably the most important and most characteristic association of this territory. Here it expresses Saharo-Sindian conditions just as *Artemisietum Herbae albae* expresses Irano-Turanian conditions. We observed this association both in the eastern and the western

parts of this territory. In the environs of Basra-Ur it occupies large tracts, being everywhere confined to sandy but not altogether loose soils. *Haloxylon salicornicum*, the "rimth" of the Arabs, is, according to MUSIL (1927) and other explorers of Arabia a rather common plant in the central part of this territory also.

(2) *Rhanterietum epapposi*. This is no less important than the former association, both in distribution and in expressing east Saharo-Sindian conditions. We observed it almost exclusively in the eastern part of this territory (South and West of Basra), where it is very abundant in compact sandy and sand-gravel soil. We also found single specimens of *Rhanterium epapposum* on the northern edge of Wadi Sirhan. Most students of Arabia report it in various parts of North Arabia. It is the well known "Arfaj" of the Arabian tribes in the Syrian Desert and Northern Arabia, which, although much spoken of by non-botanical explorers of Arabia, is little known to the botanist of these countries. It is probably the same plant mentioned by MUSIL (1927) and VELENOVSKY (1921-22), as *Musilia arabica*. Its taxonomic value remains to be elucidated. *Rh. epapposum* is a branching and somewhat shrubby Composite used by the Beduins for fuel¹ and camel food.

(3) *Zizyphetum nummulariae*. This we observed only once in the Wadi Muhammadi west of Ramadi. Single shrubs of *Zizyphus nummularia* are found in the environs of Luqait (between Basra and Ur) also. HANDEL MAZZETTI (1912-14) records it also from the right bank of the Tigris between Baghdad and Tekrit. It is thus limited only to the eastern part of the Saharo-Sindian territory.

(4) *Haloxylonetum persici*. This is the most interesting community of the Saharo-Sindian territory. We observed twice it in Edom, in 1929 and 1936. Because of its importance some details may be added here on the distribution of *Haloxylon persicum* in this and in the adjoining country. Besides Edom (south of Quweira), we possess information of its occurrence in Ghor es Safi (SE end of the Dead Sea) and in Ghor Feifeh (E of Wadi 'Araba), also observed here by AARONSOHN and determined as

¹ In the environs of Basra we saw camels laden with these plants, for the markets of Basra. There are several localities in the Saharo-Sindian territory named after the arabic name of this plant (Arfajie etc.).

H. Ammodendron by OPPENHEIMER (1930). It is recorded by MUSIL (1927) in many localities in the vicinity of Wadi Sirhan and the Jauf. In the same and in other parts of North Arabia, especially in the Nefud, it is mentioned by PELGRAVE (l.c.), BLUNT (l.c.), EUTKINS (l.c.), CARRUTHERS (l.c.), PHILBY (l.c.), CHEESMAN (l.c.) and others: all using its Arabic name: Ghadha, Gadha, Ghada or Raza (MUSIL), without being able to identify it botanically. *Haloxylon persicum* is a tree like shrub, 2-6 m. in height with a white bark and brittle branches, and resembles *Ephedra* or *Tamarix*. It is strictly confined to sandy soils and is chiefly characteristic of dunes and valleys. For the Beduins of the Desert it is one of the few useful desert trees, supplying camel food, timber and fuel. *H. persicum* is known from Central Asia and Persia as a tree of the well known "saxaul" forests.

(5) On sandy habitats, mainly in sand dunes, there also occurs *Calligonetum comosi*. This seems to be common in the Syrian Desert. We observed it only between Basra and Ur and S of the Dead Sea, but various travellers record it as the arabic "Yarta" in the interior of this Desert.

We also observed the following plant communities:

(6) *Andropogonetum lanigeri*¹ in the eastern part of the territory.

(7) *Convolvuletum oxyphylli* in the environs of Zubair.

(8) *Heliotropietum persicae*, between Basra and Ur.

(9) *Haloxylon salicornicum*—*Teucrium Olivieri* association, between Basra and Ur.

(10) *Retametum Roetami*. This was found by us only in the environs of Qasr Azraq and on mountain sides facing the Jordan Valley, both on limestone. This is the northernmost station of this association occurring both in sandy and in stony habitats.

(11) *Artemisietum judaicae* was observed in the southwestern part of the territory (between Quweira and 'Aqaba).

We also wish to mention here some associations of rather rare occurrence in the Syrian Desert. These are: *Zygophylletum dumosi* (EIG, l.c.), *Artemisietum monospermae* (EIG, l.c.), *Anabasis articulata* — *Zilla spinosa* association, (EIG, l.c.), etc. (Plate IV A).

¹ We are not yet quite sure about the specific name of the leading plant of this association.

Finally a series of species may be mentioned, which are very important vegetationally, being leading plants or important associates in various associations not quoted here. Such are, for example: *Scrophularia hypericifolia*, *Atractylis flava*, *Lycium barbarum*, *Ephedra alata*, *Farsetia aegyptiaca*, *Danthonia Forskahlei*, *Atriplex leucoclada*, *Astragalus kahircicus*, *Ferula sinaica*, *Aristida obtusa*, *Heliotropium luteum*, *Lithospermum callosum*, *Fagonia Bruguieri*, etc.

The most important halophytic and hydrophytic associations have already been mentioned in the chapter dealing with the Irano-Turanian vegetation.

(4) *The Sudano-Deccanian element*

As we have already pointed out, in Sinai, Palestine and the Syrian Desert, this element constitutes a series of enclaves each, more or less remote from one another, and forming a small oasis within the Saharo-Sindian territory. These enclaves bear a savanna-like vegetation composed of some arboreal species often thinly scattered, with or without a prominent grassy or herbaceous layer between trees.

The Sudano-Deccanian element is represented in the Syrian Desert by 24 species, mostly trees and shrubs. Except in the Jordan Valley and Wadi 'Araba, the plants of this element do not play any important part in the vegetation of the Syrian Desert. The most important stations of this vegetation in the Jordan Valley and Wadi 'Araba are: Ghor Feifeh, Ghor es Safi, Wadi Zara, Ein Gedi, Jericho, Shittim Plain, Wadi Auja. But there are, in addition a good many latitudinal wadis and depressions emptying into the eastern shore of the Dead Sea, which exhibit a Sudano-Deccanian flora.

One of the most developed savanna-like stands is to be found in Ghor es Safi. Two thirds of the 24 Sudano-Deccanian species are encountered here. The tall grass, *Eragrostis bipinnata*, often present as undergrowth, gives the "savanna" a vivid appearance.

In the interior of the Syrian Desert (N of the 30th parallel) Sudano-Deccanian enclaves do not exist, though solitary specimens of this element are encountered here and there in wadis and oases.

The most remarkable and widespread tree of this element is

Zizyphus Spina Christi, which reaches the northern limit of its distribution area in Syria and Iraq.¹ It is very common in the Jordan Valley, occurs also in the Jauf and in Baghdad, where it is probably cultivated for its edible fruits. Of the other important constituents of the Sudano-Deccanian flora the following may be mentioned: *Salvadora persica*, *Balanites aegyptiaca*, *Cordia Gharaf*, *Maerua crassifolia*, *Moringa aptera*, *Acacia Seyal*, *A. tortilis*, *A. spirocarpa*, *Callotropis procera*, *Solanum incanum* and *Capparis decidua*. Less important phytosociologically are *Loranthus Acaciae*, *Cocculus pendulus*, *Boerhavia repens*, *Tephrosia Apollinea*, *Abutilon muticum*, *Leptadenia pyrotechnica*, *Pentatropis spiralis*, *Zygophyllum simplex*, *Pluchea Dioscoridis*, etc.

For the majority of the Sudano-Deccanian plants of the Syrian Desert, the Middle Jordan Valley is the most northerly point in their distribution area. (Plate IV C).

The ecological relations of these plants are very interesting. Requiring a more or less high temperature, and a sufficient rate of moisture they are confined chiefly to the Jordan Valley and there only to the vicinity of watercourses, or to deep soils rich in moisture. Since the ecology and the migration history of these plants have been closely studied by EIG (1931), we need not go into details upon this subject.

(5) *The Eurosibero-Boreoamerican element*

This group consists of 10 species and is of little significance in the Syrian Desert. Ecologically, the plants of this group are strictly confined to hydrophytic and hemerophytic habitats.

(ii) *The bi-regional and pluri-regional plant groups*

(1) *The Mediterraneo—Irano-Turanian group of connection*

This group is represented by 368 species, i.e. by 18% of the total number of species of the country. Ecologically this group includes the following plants:

(a) A large number of plants belonging to this group are strictly confined to halophytic, hydrophytic and hemerophytic habitats. Thus these plants do not characterise any region, since their distribution area is chiefly controlled by edaphic factors.

¹ Known also in Aleppo, Alexandretta as well as in Kurdistan (after HANDEL-MAZZETTI, 1912-14), but is no doubt cultivated there.

This group also includes a series of plants, which, in some Mediterranean countries, are true segetal plants, while in some Irano-Turanian countries they are confined to primary habitats. For such a plant group the penetration from the Irano-Turanian region into Mediterranean countries is easily demonstrable. This striking process is, of course, conditioned by the incessant destruction of the Mediterranean primary vegetation by man. On the other hand there is actually no penetration of Mediterranean plants into the Irano-Turanian communities. This fact is of great phytogeographical significance, since it throws much light on the question of the origin of some segetal plants common in Mediterranean countries.

(b) Another series of Mediterranean—Irano-Turanian plants is confined in the Irano-Turanian region to Mediterranean enclaves or other special Mediterranean habitats. Such enclaves are, for instance: Jebel Druz in the Syrian Desert, the environs of Zawita in Iraqi Kurdistan, many localities in Persia, and probably elsewhere. In reality the plants of this group could be regarded as truly Mediterranean.

(c) Finally there are numerous plants in this group which are limited to a district considered as transitional between the Mediterranean and Irano-Turanian regions. Such a borderland must naturally contain plants belonging to both regions under consideration. This is particularly true of the north-western part of the country, where the transition area is rather broad.

Phytogeographically this group of connection is composed of the following series:

(a) Mediterranean—Irano-Turanian (incl. sub Mediter.—Ir.-Tur.) — 227 species. Of these, 158 are segetal plants (among them 147 therophytes), 7 are ruderal, and the remainder are plants of primary habitats (of these 21 are hydrophytes and halophytes, 9 are chasmophytes).

(b) East Mediter.—Ir.-Tur. — 128 species. Of these, 34 are segetal plants, the remainder being of primary habitats. A considerable number of the latter are inhabitants of Mediterranean—Irano-Turanian transitional areas, of Mediterranean enclaves, or of penetration areas within the Irano-Turanian region.

(c) North Med.—Ir.-Tur. — 15 species.

(d) South Med.—Ir.-Tur. — 10 species.

We may, therefore, summarize this chapter as follows: The occurrence of such a high proportion of plants common to two regions does not necessarily obliterate the distinguishing characters between the two regions for the following reasons: (1) Some of these plants are confined to secondary habitats in both regions or only in the Mediterranean. (2) Others include "edaphic specialists" (hydrophytic, halophytic plants). (3) A good many from this group consists of inhabitants more or less strictly confined to areas of transition between these two regions. (4) Finally, there is a considerable number of plants belonging to this group which are limited to Mediterranean enclaves and penetration districts within the Irano-Turanian region. At any rate, future taxonomic investigation will no doubt markedly reduce the total number of plants of connection by establishing that some of these biregional species are of a heterogeneous nature, and may be split up in to minor monoregional species.

(2) *Mediterrano—Saharo-Sindian group of connection*

This group consists of 6 species only, since the two regions in question are quite remote from one another, both geographically and ecologically.

(3) *The Mediterrano—Eurosibero-Boreoamerican group of connection*

This group contains 22 species. Some are hydrophytes, others seem to be represented in the Mediterranean countries by special forms; taxonomical revision of these species may reduce this number considerably.

(4) *The Saharo-Sindo—Irano-Turanian group of connection*

Contains 35 species. Considering the fact that these two regions are contiguous in North Africa, Iraq, Persia, etc., this figure is very insignificant in comparison with those of other biregional groups. This fact further emphasises the phytogeographical autonomy of each of these two regions.

Many plants of this group are psammophytes, halophytes and hydrophytes, e.g.: *Arnebia decumbens*, *A. linearifolia*, *Tetradiclis salsa*, *Frankenia hirsuta*, *Anabasis setifera*, *Salsola Rosmarinus*, *Bassia latifolia*, *Haloxylon persicum*, etc.

Another series of this group of connection is represented by *Leontodon hispidulum*, *Astragalus bombycinus*, *A. corrugatus*, *A. gyzensis*, etc. These plants seem to be ecologically true Saharo-

Sindian species, occupying habitats of extreme desert conditions in Irano-Turanian territories.

There remains a number of plants belonging to this group which are truly biregional, e.g. *Elymus Delileanus*, *Koeleria linearis*, *Astragalus tribuloides*, *Gastrocotyle hispida*, *Lappula spinocarpus*, *Senecio coronopifolia*, *Ephedra alata*, *Salvia lanigera* and *Peganum Harmala*. The latter is one of the most striking ruderal or sub-ruderal plants in Irano-Turanian and Saharo-Sindian countries confined to birs or wadis, frequently visited or inhabited by shepherds and nomads.

Populus euphratica as well as a few other hydrophytes also belong to this group. The former is phytosociologically very significant, being a leading plant of the *Populetum euphraticae* (Erg, l.c.), in the Lower Jordan Valley and the Euphrates. The ecological requirements of *P. euphratica* are Saharo-Sindian rather than Irano-Turanian.

(5) *The Saharo-Sindo—Sudano-Deccanian group*

This group is represented here by 20 species. According to their ecological relations it seems to us that some plants of this group are to be considered Sudano-Deccanian rather than plants of connection. Such, for example, are: *Eragrostis bipinnata*, the leading plant of the *Eragrostetum bipinnatae* in the Jordan Valley, *Daemia obcordata*, *Panicum turgidum*, *Cucumis prophetarum*, *Aerva tomentosa*, *Lavandula coronopifolia*, *L. pubescens*, *Orchradenus baccatus*, *Andropogon foveolatus*.

On the other hand we believe that the following plants from this group of connection belong rather to the Saharo-Sindian element and that their occurrence within Sudano-Deccanian countries is confined to Saharo-Sindian areas (penetration areas or enclaves). These are: *Asphodelus tenuifolius*, *Aristida ciliata*, *A. obtusa*, *Pulicaria crispa*, *P. undulata*, *Zygophyllum coccineum*, etc.

(6) *The Med.—Ir.—Tur.—Sah.—Sindian group*

This consists of 11 species. We shall mention only the most important of them: *Stipa tortilis* (covering immense tracts in various associations of the Irano-Turanian territory), *Bromus tectorum*, *Schismus barbatus*, *Sch. arabicus*, *Stipa Lagascae*, *Teucrium Polium*. The latter is a widely variable species, so that

each of the three regions dealt with here may be represented by a particular form.

(7) *The Med.—Ir.—Tur.—Eurosib.—Boreoamerican group*

This is the largest of the pluriregional groups, consisting of 83 species. Halophytes — 3 species; hydrophytes and sub hydrophytes — 30 species; segetal and ruderal plants — 30 species; diverse — 20 species.

(8) *The Tropical group*

This consists of 15 species mostly hydrophytes or sub hydrophytes.

(9) *The Boreo—Tropical group*

Contains 60 species. All halophytes and weeds.

(10)–(13) *The Mediterraneo—Tropical group (5 species), the Mediterraneo—Irano—Turano—Tropical group (14 species), the Mediterraneo—Saharo—Sindo—Tropical group (2 species) and the Mediterraneo—Irano—Turano—Saharo—Sindo—Tropical group (11 species)*

Consists mainly of halophytes, hydrophytes and weeds of irrigated crops, for example: *Panicum repens*, *Typha angustata*, *Withania somnifera*, *Fimbristylis dichotoma*, *Cyperus glaber*, *Alternanthera sessilis*, *Scirpus littoralis*, *Juncus Fontanesii*, *Lippia nodiflora*, *Juncus punctorius*, *Imperata cylindrica*, *Frankenia pulverulenta*, *Cressa cretica*.

(14) *The Sudano—Deccano—Tropical group*

Only one plant belongs to this group: *Hyphaene thebaica*. It reaches its northernmost limit of distribution in Aqaba where we noticed only a single specimen.

To summarise this chapter we wish to add that the biregional and pluriregional groups of the Syrian Desert contain 659 species, constituting 32% of the total number of species. These groups are scattered over various phytogeographical territories in the country and are, on the whole, of a rather high phytosociological value as edicators of the most of the hydrophytic, halophytic and hemerophytic plant associations.

Another instructive point emerging from this analysis is that the percentage of plants confined to special edaphic (hydrophytic, halophytic, hemerophytic) habitats is considerably lower among

the biregional than among tri- and pluriregional groups, in other words, the more phytogeographical regions a species is able to inhabit, the more is it restricted in its edaphic requirements.

(iii) *Endemism*

In what follows, a list of endemic species hitherto discovered in the Syrian Desert¹ will be given. It does not claim to be complete, as our knowledge of the flora of this country is still very imperfect. While a monographical revision of the important genera and thorough investigation of certain tracts as yet unexplored by botanists will no doubt lead to the discovery of a large number of new species within this country, further studies of the flora of Arabia, Mesopotamia, Kurdistan, Persia, etc. will markedly reduce the number of endemic species listed here. This list demonstrates the ability for species formation of this flora, the relations of the different elements to endemism and the localisation of the main centres of endemism.

We distinguished between three groups of endemics: the Mediterranean, Irano-Turanian and Saharo-Sindian.

THE EAST MEDITERRANEAN ENDEMICS:

<i>Triodia glaberrima</i> Post	<i>Aethionema gileadense</i> Post
<i>Carex eremitica</i> Paine	<i>Sedum Steudeli</i> Boiss.
<i>Arum melanopus</i> Boiss.	<i>Trifolium velivolum</i> Paine
<i>Allium lachnophyllum</i> Paine	<i>Astragalus gileadensis</i> Eig
<i>Iris histrioides</i> Forst.	<i>Daphne linearifolia</i> Hart
<i>Sternbergia Sparfordiana</i> Dinsm.	<i>Rubia velutina</i> Nab.
<i>Silene physalodes</i> Boiss.	<i>Anthemis emasensis</i> Eig

THE SAHARO-SINDIAN ENDEMICS:

<i>Ammochloa unispiculata</i> Eig	<i>Thymus Musilii</i> Vel.
<i>Bellevalia bracteosa</i> Vel.	<i>Plantago maris-mortui</i> Eig
<i>Barbarea arabica</i> Vel.	<i>Matricaria arabica</i> Vel.
<i>Psoralea flaccida</i> Nab.	<i>Pyrethrum Musilii</i> Vel.
<i>Tephrosia Musilii</i> Vel.	<i>Anthemis maris-mortui</i> Eig
<i>Tamarix Jordanis</i> Boiss.	<i>Centaurea calcitrapella</i> Bornm. et Dinsm.
<i>Helianthemum ventosum</i> Boiss.	
<i>Scorodosma arabica</i> Vel.	<i>C. camelorum</i> Vel.
<i>Daucus jordanicus</i> Post	<i>Scorzonera Musilii</i> Vel.
<i>Trichodesma Boissieri</i> Post	

¹ We have also included here a few species which were also found in the borderland of the adjacent countries.

THE IRANO-TURANIAN ENDEMICS:

- Poa macroglossa* Hack.
Lepturus pubescens (Bert.) Boiss.
Biarum Russelianum Schott
Colchicum halepense Freyn
C. fasciculare L.
Asphodeline recurva Post
Fritillaria Hermonis Fenzl.
Allium schergianum Boiss.
A. karyeteini Post
Bellevalia stepporum Feinbr.
B. palmyrensis Feinbr.
B. densiflora Boiss.
B. Mosheovii Feinbr.
Muscari albicaulis Post
M. Aaronsohnii Opphr.
Asparagus filifolius Bert.
Crocus moabiticus Bornm. et Dinsm.
Iris melanosticta Bornm.
I. petrana Dinsm.
I. nigricans Dinsm.
I. auranitica Dinsm.
Polygonum corrigioloides
Jaub et Sp.
P. aleppicum Boiss. et Haussk.
Gypsophila hygrophila Post
G. Antari Post et Beauverd
Herniaria arabica Hand.-Mazz.
Delphinium Gombaultii Thieb.
Cleome Kotschyana Boiss.
Matthiola damascena Boiss.
Malcolmia auranitica Post
Hesperis pulmonarioides Boiss.
Erysimum Blancheanum Boiss.
Crysocamela velutina DC.
Alyssum meniocoides Boiss.
Texiera glastifolia DC.
Sedum Lousii Thieb. et Gomb.
Prunus antilibanotica Post et
Dinsm.
Amygdalus arabica Oliv.
Trifolium plebeium Boiss.
T. alsadami Post
Chesneya Olivieri Jaub. et Sp.
Astragalus Aaronsohnii Eig
A. adpressiusculus Eig
A. aleppicus Boiss.
A. Antilibani Bge.
A. Butleri Post et Beauverd
A. conduplicatus Bert.
A. damascenus Boiss. et. Gaill.
A. deserti-syriaci Eig
A. dorcoceras Bge.
A. duplostrigosus Post et Beauverd
A. Faktorovskiy Eig
A. lepidanthus Boiss.
A. megaloceras Sam.
A. moabiticus Post
A. nitidulus Hand.-Mazz.
A. ocephalus Boiss.
A. palmyrensis Post.
A. psilodontus Boiss.
A. Samuelssonii Eig
A. spicaeformis Eig
A. trachoniticus Post
A. transjordanicus Sam.
A. zemeraniensis Eig
Onobrychis Wettsteinii Nab.
O. Gaillardoti Boiss.
Linum Peyronii Post
Fagonia Olivieri DC.
Althaea chrysantha Sam.
Reaumuria alternifolia (Labill.)
Grande
Haplophyllum deserti Post
et Beauverd
H. fruticosum (Labill.) Boiss.
H. Chesneyanum Boiss.
H. Blanchei Boiss.
Polygala edumea Zohary
Pimpinella petraea Nab.
Scandix damascena Bornm.
Ferula palmyrensis Post et Beauverd
F. orbicularis Post
F. Blanchei Boiss.
F. Bilasi Post
F. Barbeyi Post
Ferulago auranitica Post
Prangos deserti Post et Beauverd.
Anisosciadium isosciadium Bornm.
Euphorbia Postii Boiss.
E. Chesneyi Kl. et Gcke.
Statice palmyrensis Post
Paracarium lamprocarpum Boiss.
P. velutinum Post

<i>Nonnea palmyrensis</i> (Post.) Sam.	<i>A. Handel-Mazzettii</i> Eig
<i>Teucrium auraniticum</i> Post	<i>A. Aaronsohnii</i> Eig
<i>T. coniortodes</i> Boiss. et Bl.	<i>A. edumaea</i> Eig
<i>T. socinianum</i> Boiss.	<i>A. breviradiata</i> Eig
<i>Salvia longipes</i> Zohary	<i>A. deserti-syriaci</i> Eig
<i>S. Pinardi</i> Boiss.	<i>A. homalolepis</i> Eig
<i>Micromeria Shepardi</i> Post	<i>A. nabataea</i> Eig
<i>Molucella lanata</i> Post	<i>Cousinia moabitica</i> Bornm. et Nab.
<i>Marrubium radiatum</i> Del.	<i>C. Postiana</i> Winkl.
<i>Stachys nivea</i> Labill.	<i>C. Pestalozzae</i> Boiss.
<i>Verbascum Antari</i> Post	<i>C. Veshenii</i> Post
<i>V. damascenum</i> Boiss.	<i>C. aleppica</i> Boiss.
<i>V. tropidocarpum</i> Murb.	<i>Cynara auranitica</i> Post
<i>V. palmyrense</i> Post	<i>Onopordon macrocephalum</i> Eig
<i>Celsia glandulifera</i> Post	<i>O. lanceolatum</i> Eig
<i>C. lanceolata</i> Vent	<i>O. anisacanthum</i> Boiss.
<i>Linaria damascena</i> Post	<i>Phaeopappus longispinus</i> Post
<i>Scrophularia scariosa</i> Boiss.	<i>Centaurea stramenticia</i> Hand.-Mazz.
? <i>Cephalaria tenella</i> Paine	<i>C. damascena</i> Boiss.
<i>Pterocephalus pulverulentus</i> Boiss.	<i>C. thrinciaefolia</i> DC.
et Bl.	<i>C. trachomitica</i> Post
<i>Campanula euclasta</i> Boiss.	<i>C. Postii</i> Boiss.
<i>Achillea membranacea</i> (Lab.) DC.	<i>Scorzonera deserti-syriaci</i> Eig
<i>Anthemis tenuicarpa</i> Eig	<i>S. edumaea</i> Eig

The total number of the endemics is 171 or 8,3% of the Syrian Desert flora. Of these, 14 species, or 8,2% of the endemics are Mediterranean, 18 species (10,5%) of the endemics are Saharo-Sindian, and 139 (81,2%) are Irano-Turanian. These are very interesting figures, showing great disproportion between the number of the endemic, and the total number of species of each element. This high number (and percentage) of the Irano-Turanian endemics is especially surprising. In this connection the following points should be considered:

(1) The Irano-Turanian territory of the Syrian Desert constitutes a large part of the Mesopotamian subregion, while the Mediterranean and Saharo-Sindian territories are only small portions of the subregions to which they belong. This Mesopotamian subregion, like other Irano-Turanian subregions constitutes a separate entity on account of its floristical and vegetational peculiarities. Hence the large number of endemics among the Irano-Turanian element of the Syrian Desert.

(2) While the flora of the Irano-Turanian region has much in common with the Mediterranean and the Eurosibero-Boreo-

american floras in its generic composition, this region is strikingly distinguished from the latter in its richness in endemic species. The enormous number of Irano-Turanian species of the genera: *Astragalus*, *Onobrychis*, *Anthemis*, *Cousinia*, *Acantholimon*, *Silene*, *Allium*, *Salvia*, *Iris* and others should be remembered in this connection. These, as well as other genera (*Verbascum*, *Bellevalia*, *Ferula*, *Aegilops*, *Phlomis*, etc.) possess the peculiarity of forming so called point endemics (endemics of extremely restricted areas).

(3) Finally, it may be added that the northern part of the Syrian Desert together with the transtauroic portion of Assyria (district of Urfa, Mardin, Aintab, Marash) constitutes a large centre strikingly rich in endemics of very restricted areas. This centre comprises, in the Syrian Desert, the Palmyrenian mountains, Jebel Abiad, Jebel Bilas, Jebel Shumaria and the eastern foot hills and slopes of the Antilebanon. These mountains being ecologically highly diversified are the main seat of many Irano-Turanian endemics quoted in this list.

With regards to the systematic relation of these endemics it is true that some of them show more or less clear affinities to Mediterranean species, on the whole, however, the endemic species cited are also genetically of Irano-Turanian origin. Fuller details on this subject must be added in the future, when the wide gaps in the floristical investigation of this very attractive region will have been filled in.

SUMMARY

The Syrian Desert and its flora have been analysed from a phytogeographical standpoint, and the following main points elucidated:

(1) The flora of the Syrian Desert is made up of the following phytogeographical groups: The Mediterranean element (520 species), the Irano-Turanian element (588 species), the Saharo-Sindian (239 species), the Sudano-Deccanian (24 species), the Eurosibero-Boreoamerican (10 species), and bi- et pluri-regional groups (659 species).

(2) Phytogeographically the Syrian Desert comprises three territories: the Mediterranean, the Irano-Turanian and the Saharo-Sindian.

(3) In the Syrian Desert, the Sudano-Deccanian and Euro-sibero-Boreoamerican plants do not occupy any particular territory. The former are limited to the Saharo-Sindian territory, forming a series of enclaves along Wadi Araba and the Lower Jordan Valley, while the latter are scattered here and there in hydrophitic habitats and are unimportant in the vegetation of the country.

(4) The most important element in the Syrian Desert is the Irano-Turanian, both in number of species and in vegetational diversity. The Irano-Turanian territory, however, is smaller than the Saharo-Sindian.

(5) The Mediterranean element is poorer than the Irano-Turanian in species and occupies a comparatively narrow belt in Transjordan and an enclave in Jebel Druz. Its more or less typical East Mediterranean arboreal vegetation is largely destroyed, owing to the proximity of the steppes and deserts.

(6) The Saharo-Sindian element occupies the largest territory though its number of species is the smallest in comparison to the other constituents of the flora. Steppes and deserts are not phytogeographical entities and the vegetation of both may occur in the Irano-Turanian as well as in the Saharo-Sindian territory.

(7) The biregional and pluriregional groups of the country consist partly of halophytes and hydrophytes and partly of segetal and ruderal plants. But there is still a high proportion of plants belonging to these groups, especially to the biregional groups which are not restricted to special edaphic conditions. As an example we may mention the East Mediterranean—Irano-Turanian group of connection.

(8) The vegetational character of this country has been treated for the first time in this paper. A considerable number of plant communities has been mentioned for each of the phytogeographical territories in question.

(9) The endemic species of the country have been subdivided into Mediterranean, Irano-Turanian and Saharo-Sindian groups. There are 139 Irano-Turanian species, i.e. 23,6% of the total Irano-Turanian flora of the country, while the Mediterranean endemics do not exceed 14 (2,6% of the Mediterranean flora), and the Saharo-Sindian endemics 18, i.e. 7,6% of the Saharo-Sindian flora.

REFERENCES

- ASHBEL, D. (1930). *Die Niederschlagsverhaeltnisse im suedlichen Libanon, in Palaestina und im noerdlichen Sinai*. Berlin.
- (1938). *Rainfall tables for Palestine and adjacent countries*. Jerusalem.
- BLANCENHORN, M. (1912). *Naturwissenschaftliche Studien am Toten Meer und im Jordantal*. Berlin.
- (1914). *Syrien, Arabien und Mesopotamien*. *Hdb. reg. Geol.* V, 4: 1-157.
- BLUNT, A. (1881). *A pilgrimage to Nejd*. London.
- BOISSIER, E. (1867-1888). *Flora orientalis, I-V et Suppl.* Basileae et Genevae.
- BORNMUELLER, J. (1921). Kleiner Beitrag zur Kenntnis der Flora des Step-
pengebietes am oberen Euphrat sowie Nord-Syrien. *Beih. Bot. Ctrbl.*
Abt. II, 38: 431-457.
- CARRUTHERS, D. (1935). *Arabian adventure*. London.
- CHEESMAN, R. E. (1926). *In unknown Arabia*. London.
- DINSMORE, J. E. (1912). *The Jerusalem Catalogue of Palestine plants*. 3rd. ed. Jerusalem.
- DOUGHTY, C. M. (1933). *Travels in Arabia Deserta*. London.
- DUBERTRET, L. (1933). *Carte géologique de la Syrie et du Liban*.
- EIG, A. (1927). On the vegetation of Palestine. *Agric. Exp. Sta. Bul.* 7: 1-88.
- (1931). Les éléments et les groupes phytogéographiques auxiliaires dans la flore palestinienne. I, II. *Fedde, Rep. spec. nov. r. veg.* *Beih.* 63: 1-201, tab. 120.
- (1933). A historical-phytosociological essay on Palestinian forests of *Quercus Aegilops* L. ssp. *ithaburensis* (Desc.) in past and present *Beih. Bot. Ctrbl.* Abt. II, 51: 225-272.
- (1938a). On the phytogeographical subdivision of Palestine. *Palest. Journ. Bot. J Series*, 1: 4-12.
- (1938b). Taxonomic studies on the oriental species of the genus *Anthemis*. *Palest. Journ. Bot. J Series*, 1: 161-224.
- (1939). Systematical studies on *Astragali* of the Near East. *Beih. Bot. Ctrbl.* (In press).
- EMBERGER, L. (1939). Aperçu général sur la végétation du Maroc. *Veroeff. Geobot. Inst. Ruebel Zuerich* 14: 40-157.
- ENGELER, A. (1919). Uebersicht ueber die Florenreiche und Florengebiete der Erde. In A. ENGELER und E. GILG, *Syllabus der Pflanzenfamilien*. Berlin.
- FISCHER, H. (1919). Wirtschaftsgeographie von Syrien. *Ztschr. D. Pal. Ver.* 42: 1-112.
- GOMBALT, R. (1933). Une reconnaissance botanique dans le Djebel-el-Amiri (Syrie du Nord). *Bull. mens. Soc. Linn. Lyon* 2: 157-161.
- (1934). Plantes nouvelles pour les Etats du Levant sous mandat français. *Bull. Soc. Bot. France* 81: 595-598.
- (1937). Notules sur la flore de la Syrie. *Bull. Soc. Bot. France* 84: 465-480.

- GAJEWSKY, W. (1937). Les éléments de la flore de la Podolie polonaise. *Planta Polonica*.
- GRADMAN, R. (1934). *Die Steppen des Morgenlandes*. Stuttgart.
- GRANT, CH. PH. (1937). *The Syrian Desert*. London.
- GRISEBACH, H. (1884). *Die Vegetation der Erde*. Leipzig.
- HANDEL-MAZZETTI, H. v. (1912-1914). *Pteridophyta und Antophyta aus Mesopotamien und Kurdistan, sowie aus Syrien und Prinkipo*. *Ann. Nat. Hofmus.* 26: 1-36; 27: 1-52, 391-459; 28: 1-27.
- (1914). Die Vegetationsverhaeltnisse von Mesopotamien und Kurdistan. *Ann. Nat. Hofmus.* 28: 65 p.
- HART, H. C. (1891). *Some account of the fauna and flora of Sinai, Petra and Wâdy 'Arabah*. London.
- HOGARTH, D. G. (1904). *The penetration of Arabia*. London.
- LESCH, W. (1931). Arabien. *Mitt. Geogr. Ges. Muenchen* 24: 1-153.
- MUSIL, A. (1907). *Arabia Petraea*. Wien.
- (1927). *Arabia Deserta*. New-York.
- (1928). *Palmyrena*. New-York.
- NABELEK, F. (1923-29). *Iter Turcico-Persicum, I-V. Publ. Fac. Sci. Univ. Masaryk Brno*, Nos. 35, 52, 70, 105, 111.
- OPPENHEIMER, H. R. (1930). Reliquiae Aaronsohnianae I. Florula Transjordanica. *Bull. Soc. Bot. Genève*, 2 Sér. 22: 126-409.
- PHILEY, H. ST. J. B. (1922). *The heart of Arabia*. London.
- POPOV, M. G. (1931). Between Mongolia and Iran. *Bull. Appl. Bot. Gen. Pl. Breed.* 26, 3:
- POST, G. E. (1888). Narrative of a scientific expedition in the Trans-jordanic region in the spring of 1886. *Pal. Expl. Fund Quart. Stat.* 175-237.
- (1891). Narrative of a trip to Palmyra in April, 1890. *Pal. Expl. Fund Quart. Stat.* 20-49.
- (1932-1933). *Flora of Syria, Palestine and Sinai*. Ed. 2 revised by J. E. DINSMORE. Beirut.
- REGEL, C. (1932). Geobotanische Beobachtungen auf einer Reise in Marocco und in der Sahara. *Veroeff. Geobot. Inst. Ruebel Zuerich* 14:
- REICHERT, I. (1937). L'Afrique du Nord, sa position phytogéographique au point de vue lichenologique. *Bull. Soc. Bot. France* 84:
- RIKLI, M. und SCHROETER, C. (1912). Vom Mittelmeer zum Nordrand der Sahara. *Viertelj. schr. naturf. Ges. Zuerich* 57: 1-178.
- RITTER, C. (1852). *Map of Arabia*. Berlin.
- SAMUELSSON, G. (1935). Notes on two collections of plants from Syria, Palestine, Transjordan and Iraq. *Svensk Bot. Tidskr.* 29: 376-390.
- (1938). Cives Novae Florae Syriacae. *Fedde, Rep. sp. nov. r. veg. Beih.* 100:
- SCHUMACHER, G. (1888). *The Jaulân*. London.
- THIEBAUT, J. (1934). Notes sur quelques plantes de la flore libano-syrienne. *Bull. Soc. Bot. France* 81: 113-121.

- et GOMBAULT, R. (1932). Une excursion botanique au Djebel Tenf (désert de Syrie). *Bull. mens. Soc. Linn. Lyon* 1: 71-74.
- TRISTRAM, H. B. (1873). *The land of Moab*. New-York.
- VELENOVSKY, J. (1921-22). Arabské rostliny z poslední cesty Musilovy r. 1915 (Plantae Arabicae ex ultimo itinere A. Musilii a. 1915). *Vestník Kral. C. Spol. Nauk* 2: 1-9.
- ZOHARY, M. (1931). Zur Kenntnis der Cruciferen Transjordaniens. *Fedde, Rep. sp. nov. r. veg.* 29: 126-132.
- (1933). Neue Beiträge zur Kenntnis der Flora Syriens. *Beih. Bot. Ctrbl. Abt. II*, 51: 273-298.
- (1935). Die phytogeographische Gliederung der Flora der Halbinsel Sinai. *Beih. Bot. Ctrbl. Abt. B*, 52: 549-621.
- זֶהָרִי מ. (תרצ"ט) האלה האפלטניות בארץ-ישראל וערכה הכלכלי. „השדה“, י"ט: 22-20.
- (— (1938). *Pistacia atlantica* Desf. in Palestine and its economic value. "Hassadeh" 19: 20-22 (Hebrew).)
- (1939). To the knowledge of the flora of the Syrian Desert. *Palest. Journ. Bot. J Series* 1: 241-254.

EXPLANATION OF PLATES

- PLATE II. A.: *Pinetum halepense*. Gilead, 1927 (phot. Eig).
 B.: *Quercus calliprinos*—*Crataegus sinaica* association. Jebel Druz, 1932 (phot. Eig).
 C.: Vestiges of *Pistacietum atlanticae* in the Desert E of Gilead, 1927 (phot. Eig).
- PLATE III. A.: *Artemisietum Herbae albae*. Edom, 1936 (phot. Eig).
 B.: *Haloxylonetum articulati*. Wadi Hauran, 345 km W of Baghdad, 1933 (phot. Eig).
 C.: Gravel desert. *Halogetonetum alopecuroides*. Edom, 1936 (phot. Eig).
- PLATE IV. A.: *Zilla spinosa*—*Noea mucronata* association. Nubian sandstone sands. Edom, 1936 (phot. Eig).
 B.: *Tamarix mannifera*—*Arthrocnemum glaucum* association. Salt marshes, south end of Dead Sea, 1939 (phot. Zohary).
 C.: *Zizyphus spina Christi*—*Salvadora persica* association. Ghor es Safi (SE of Dead Sea), 1939 (phot. Zohary).



A



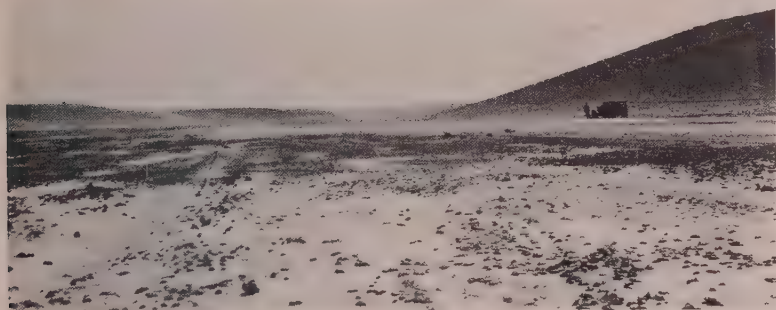
B



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A



B



C

PLANTS NEW FOR PALESTINE II¹

BY A. EIG AND N. FEINBRUN

Convolvulus oleaeifolius Desr. var. *pauciflorus* Feinbr. var. nov.*Flores solitarii vel laxae cymosi, non ut in typo subcapitati.*

JD: E of Beni Na'im (1934 EFZ). NN: Beersheba to Qurnub, 500 m. (1934 EFZ); Naqb Zuweira to Wadi Harbieh (1934 EFZ); Jerusalem to Beersheba (1935 EFZ).

Myosotis uncata Boiss. et Bl.—Boiss. 4: 245.

UG: Peki'in to Jebel Jermak (1926 EZ); Hurfesh (1927 Smoly).

Lappula sessiliflora (Boiss.) Bornm.—Bornm. Fl. Lib. u. Antilib: 243 (1914).

E: 26 km S of Ma'an (1929 EZ).

Trichodesma africanum (L.) R. Br. var. *heterotrichum* Bornm. et Kneuck.—Post 2: 254.

FN: W of el Masri; NW of 'Aqaba (1936 EFZ). LJ: Ein Gedi (1926 EFZ).

Verbascum sinaiticum Bth. var. *judaicum* Murb.²—Murb. Monogr. Verb: 237.

JM: Jerusalem (1929 E). A: Amman (1929 EZ). E: Petra (1929 EZ).

Verbascum Gaillardoti Boiss.²—Boiss. 4: 322.

UG: Beth Dajan to Jebel Jermak (1926 EZ). LG: Sejera (1929 E). EP: Balfouria to Tel Adashim (1926 Z). CA: Mt. Carmel (1927 EFZ). SA: Bath Shelomo (1927 Z).

Teucrium procerum Boiss. et Bl. var. *brevidens* Feinbr. var. nov.*Nuculae ad apicem crispo-hirtulae; calycis dentes tubo subbreviares triangulari-lanceolati, typi dentibus breviores; calyx 4-5 mm. longus.*

S: Env. of Pardess Hanna, light soil (1932 EZ).

Differs from type by shorter calyx (4-5 mm., not 6-7 mm. long), whose teeth are somewhat shorter than tube (not somewhat longer than tube). The mericarps are crisp-hirtulous, not pellucid-pruinose, as described by BOISSIER. We propose to change the description as follows: "*nuculis pellucido-pruinosis vel dense crispo-hirtulis*".*Teucrium scordioides* Schreb.—Boiss. 4: 813.

AP: Kishon river (1923 E). S: Hedera (1921 E). CS: Wadi Rubin (1926 EFZ). UG: Kefar Gileadi (1922 E).

¹ The abbreviations given are to be read as follows:

DISTRICTS: AR=Wadi Araba; A=Amman; AP=Acre Plain; CA=Carmel; CN=Coastal Plain of Negeb; CS=Coastal Plain of Shephela; DA=Desert Part of Amman; DG=Desert Part of Gilead; E=Edom; EP=Esdraselon Plain; FN=Far Negeb; G=Gilead; GO=Golan; HP=Huleh Plain; J=Judean Mountains; JD=Judean Desert; LG=Lower Galilee; LJ=Lower Jordan Valley; M=Moab; NN=Near Negeb; S=Sharon; SA=Samaria; SH=Shephela; UG=Upper Galilee; UJ=Upper Jordan Valley.

COLLECTORS: E=A. Eig; F=N. Feinbrun; Z=M. Zohary.

² Determined by MURBECK.

Scutellaria gallericulata L. var. *pubescens* Bth.—Hegi V, 4: 2511.

HP: Marshes of Huleh, open place, in *Cyperetum Papyri* (1935 R. T. Jones).

Ballota philistea Bornm.—Post 2: 391.

S: Zichron Jacob to Caesarea (1924 E). CS: Tel-Aviv (1922 E). CN: Gaza (1924 E).

Statice graeca Poir.—Boiss. 4: 862.

AP: Ras el Naqura (1925 E).

Rumex crispus L. var. *unicallosus* Peterm.—Hegi III: 177.

HP: Marshes of Huleh (1926 EZ).

Rumex conglomeratus Murr.—Boiss. 4: 1010.

S: Gan Shemuel (1922 E). HP: Banks of Jordan, N of Lake of Huleh (1933 EFZ).

Rumex pulcher L. var. *palaestinus* Feinbr. var. nov.

Valvae fructiferae triangulari-oblongae, plerumque inaequaliter calliferae, apice integrae, acutiusculae, 6-7 mm. longae, utrinque dentes 3-4-5 ob-sitae; dentes dimidiam latitudinem valvae aequantes vel breviores; nerves valde prominentes; folia basalia panduriformia.

S: Benjaminia (1926 Z). CS: Rishon le Zion (1925 E). EP: Abu Shusha (1927 EFZ). CA: Esfia (1929 Gabrielith). G: Slopes facing Jisr (1927 EFZ).

This is the common form of this species in Palestine. Its most prominent characteristic is the size of the fruit which exceeds that recorded by RECHINGER. For lack of material for comparison we are not sure whether this form should be placed in the ssp. *eu-pulcher*. The specimens reported by RECHINGER from Palestine as ssp. *anodontus* belong in our opinion to this new variety.

Rumex pulcher L. ssp. *divaricatus* (L.) Murb.—Rechinger, Beih. Bot. Ctrbl.

II, 49: 35 (1932).

UG: Methula (1923 E); Tarshiha to Peki'in (1926 EZ).

Confined in Palestine to the northern district.

Rumex cassius Boiss.—Boiss. 4: 1013.

UG: Hurfesh to Peki'in (1925 E); Beth Dajan to Jebel Jermak (1926 EZ).

We do disagree with RECHINGER (l.c.p. 38) on his considering this plant a ssp. of *R. pulcher*. Morphologically it is distinguished by several important characteristics, such as unbranched or scarcely branched stem, broad-elliptical basal leaves, very long teeth of fruit and above all pedicels jointed near base. Ecologically too *R. cassius* differs from *R. pulcher*, the latter being confined to marshes, the former to maqui and forests.

Rumex bucephalophorus L. var. *papillosus* Feinbr. var. nov.

Differt a typo pedunculis et valvis papillois vel glanduloso-papillois.

S: Herzlia to Arsuf (1926 Z). CS: Tel Aviv (1928 F); Ruhama (1928 EFZ). G: Descent to the Jabbok river (1927 EFZ).

Polygonum scabrum Poir. var. *glabrescens* Feinbr. var. nov.

Ochreolae eciliolatae, ochreae glabrae, non adpresso-setulosae.

S: Hedera, Birketh Batih (1926 EZ). CS: Nebi Rubin (1926 EFZ); Yarkon river (1930 E). HP: Jordan N of Lake of Huleh (1926 EZ).

We also possess some transitional specimens with ciliate ochreoles and glabrous ochreas.

Polygonum nodosum Pers. — Boiss. 4: 1030.

CS: Wadi Misrara (1924 E); Nes Ziona (1926 EFZ). UG: Kefar Gileadi (1924 EZ); Safed (1921 E). EP: Balfouria (1925 E); Nahalal (1922 E). HP: Huleh, near el Buweiziya (1924 E). UJ: Ayeleth Hashahar (1923 E).

This plant was reported from Palestine as *P. lapathifolium* L. It is only rarely found as an annual.

Polygonum acuminatum Kth.—DC. Prodr. 14: 114.

CS: Wadi Misrara (1924 E). HP: N corner of the Lake of Huleh (1933 EFZ), forming large stands.

New for the Flora of BOISSIER as well as for the Northern Hemisphere in general; known from S Africa and S America. Not reported from Egypt. In its Palestinian stations forming rather large stands. Our specimens probably belong to var. *Humboldtii* Meisn.

Polygonum lanigerum R. Br.—Boiss. 4: 1030.

S: Birketh 'Ata, near Hedera (1926 EZ); Hedera (1919).

Polygonum senegalense Meisn.—Boiss. 4: 1031.

S: Birketh 'Ata, near Hedera (1926 EZ). HP: Huleh, near el Buweiziya (1924 E).

Polygonum aviculare L. ssp. *heterophyllum* (Lindm.) A. et G. var. *erectum*

Roth.—Hayek, Prodr. 1: 111 (1927).

S: Ben Shemen (1923 E). EP: Ein Harod (1922 E); Merhavia (1922 E).

Polygonum aviculare L. ssp. *equale* (Lindm.) A. et G. var. *procumbens* (Gilib.) Hayne.—Hayek, Prodr. 1: 111 (1927).

LG: Sarona (1924 E). UJ: Degania (1925 E). LJ: Lisan (1925 E); Jericho, 230 m. (1912 Meyers et Dinsmore).

Polygonum aviculare L. ssp. *equale* (Lindm.) A. et G. var. *condensatum* Becker.

UG: Safed (1922 E). JM: Jerusalem (1926 E).

Polygonum equisetiforme S. et S. var. *arenarium* Eig et Feinbr. var. nov.

Differt a typo: culmis erectis; perigonio majore (4 mm. longum, 4-5 mm. latum, nec 2.5 mm. × 3-3.5 mm.); lobis late-ovatis nec spatulatis, fructifero aperto; achaeniis majoribus usque ad medium exsertis; foliis etiam ramorum juvenilibus revolutis; inflorescentio fere non ramosa, laxa, longa; habitat in arenosis.

S: Env. of Hedera, sands (1932 EZ). CS: Nahlat Jehuda, sands (1937 EZ, Grizi); env. of Tel Aviv (1937 EFZ).

This form is characterized by its erect growth. Ecologically it is confined to sandy plant associations, as the *Ammophila arenaria*-*Cyperus conglomeratus* association, as well as to initial stages of the *Artemisia monosperma*-*Cyperus mucronatus* association.

Euphorbia granulata Forsk.—Boiss. 4: 1087.

FN: Ras el Naqb (1936 EFZ).

Euphorbia densa Schrenk.—Boiss. 4: 1091.

E: Queira (betw. Ma'an and 'Aqaba) (1929 EZ).

Euphorbia kahirensis Raeusch (= *E. cornuta* Pers.)—Post 2: 495.

CN: 'Arish (1925 E). NN: Wadi Sini (1928 EFZ). FN: 18 km S of el Kuntilla (1936 EFZ). DA: 30 km W of 'Azraq (1936 Dinsmore No. 11813).

E: At the junction of Wadi el Bateiha and W. el Madeifen (1936 EFZ).
Euphorbia isthmia Taeckholm—Sv. Bot. Tidskr. 26: 374 (1932).

NN: Beersheba to 'Asluj (1929 EZ); env. of Qurnub. E: Wadi el Hasa (1936 EFZ).

Salix acmophylla Boiss. f. *latifolia* Goerz¹.

LJ: Wadi Nimrin, near Shittin Plain (1929 EZ).

Salix acmophylla × *alba*¹

AP: Acre (1926 EZ). S: Birketh Batih, near Hedera (1926 E). CS: Yarkon river (1924 E). UG: Wadi Tawahin (1926 EZ). J: Beth Guwrin (1929 Gabrielith). UJ: Kinnereth (1922 E). A: Amman (1929 E).

Salix acmophylla × *babylonica*¹.

CS: Wadi Misrara (1922 E). UG: Merj Ayun, Ain Dardara (1924 E).

LG: Kefr Kilah (1925 Smoly).

Salix acmophylla × *australior*¹.

CS: Wadi Misrara (1924 E). UJ: Tabigha (1927 Dinsmore, No. 1415).

LJ: Tell Hum (1927 Dinsmore No. 3115).

Salix alba × *australior*¹.

AP: Acre (1926 E). UG: Wadi Tawahin (1926 E). EP: Nahalal (1922 E). UJ: Banks of Jordan (1923 E).

Salix alba × *babylonica*¹.

CS: Wadi Misrara (1922 E). A: Amman (1929 EF).

Salix australior Ands¹.—Post 2: 530.

UG: Hasbani (1925 Smoly).

Halophila stipulacea (Forsk.) Asch.—Boiss. 5: 3.

AR: Golf of 'Aqaba, near the coast (1936 EFZ).

Vallisneria spiralis L.—Boiss. 5: 3.

HP: Huleh (1935 R. T. Jones).

Alisma lanceolatum With.²—Samuelsson, Ark. Bot. 24 A: 21 (1932).

S: Hedera (1924 E). CS: Wadi Rubin (1926 EFZ). S: Kefar Witkin (1939 Z). EP: Balfouria (1924 E). HP: near el Buweiziya (1924 E).

A. *Plantago aquatica* L. should be excluded from the list of Palestinian plants.

Potamogeton fluitans Roth—Boiss. 5: 15.

S: Nahr el Falik (1928 EFZ). CS: Wadi Rubin (1923 F Amdursky).

UG: Wadi Karn (1926 EZ). EP: Kishon (1932 EF). UJ: Jordan near Bithania (1925 E).

This species was mistaken for *P. natans* L. which does not occur in Palestine.

Potamogeton trichoides Cham. et Schlecht.²—Asch. u. Graeb. 1: 347.

S: Birket 'Ata, near Hedera (1926 Z); Nahr-el-Falik (1929 EFZ).

Potamogeton pectinatus L. var. *scoparius* Wallr.—Hegi 1: 137.

JM: Solomons Pools (1926 E; 1923 Dinsmore No. 1936).

Ruppia maritima L.²—Post 2: 543.

AP: Kishon river, near Haifa (1923 E); Acre (1926 EFZ).

¹ Determined by GOERZ.

² Determined by SAMUELSSON.

Zostera nana Roth.—Boiss. 5 : 25.

AP: Acre, in water near coast (1935 EFZ). CS: Tel Aviv (1940 Rayss).

Lemna minor L.—Boiss. 5 : 29.

E: Qal'at Aneze, pool, 1050 m. (1936 EFZ). New for Transjordan.

Hyphaene thebaica (Del.) Mart.—Boiss. 5 : 46.

AR: N shore of the gulf of 'Aqaba, NW of the town, sand (1936 EFZ). Reported from the same locality by HART.

Epipactis latifolia (L.) All.—Boiss. 5 : 87.

UG: Peki'in to Hurfesh (1926 EZ).

Allium modestum Boiss.—Boiss. 5 : 261.

JD: km 25 on the Jerusalem-Jericho road (1934 EFZ). NN: Env. of 'Asluj, sands (1928 EFZ). LJ: Jericho Plain (1935 EZ, Grizi).

Reported only by BOISSIER from south of Gaza. Rather widely spread over the Saharo-Sindian part of Palestine.

Asparagus aphyllus L.—Boiss. 5 : 337.

S: Kabara (1927 FZ); env. of Nahr el Falik (1929 EFZ). CS: Saronia (1924 E). UG: Env. of Kefar Gileadi (1924 Smoly). CA: Mt. Carmel, near Haifa (1933 E). SA: 6 km E of Tayasir, NE of Nablus, 250 m. (1934 EFZ). J: Jerusalem (1926 E); Deir esh Sheiq (1931 EF). UJ: Env. of Migdal (1929 Smoly). A: Es-Salt (1929 EZ).

We have not yet found *A. acutifolius* L. south of Nahr-el-Kelb of S Lebanon.

Tamus orientalis Thieb.—Bull. Soc. Bot. Fr. 81: 119 (1934).

UG: Env. of Odeisa (1925 Smoly). J: Jerusalem (1924 Z).

Juncus capitatus Weig.—Boiss. 5 : 361.

S: Env. of Magdiel (1927 E).

Cyperus lanceus Thunb.—Prodr. Pl. Cap.

S: Env. of Hedera, Birketh el Batih (1926, 1932 E). CS: Wadi Rubin (1926 EFZ).

Cyperus effusus Rottb.—Boiss. 5 : 369.

LJ: Callirrhoe (1926 EFZ).

Cyperus articulatus L.—Boiss. 5 : 374.

AP: Kishon, near Haifa (1936). UJ: Jordan, near Degania (1939 Palmona).

Cyperus tegetiformis Roxb. — Boiss. 5 : 373.

CS: Yarkon river (1930 E).

Cyperus latifolius Poir.—Encycl. VII: 268.

S: Env. of Hedera, Birketh el Batih (1926 EZ).

Fuirena pubescens Kth.—Enum. Pl. 2 : 182.

S: Env. of Hedera, marsh (1926 EZ).

Scirpus Tabernaemontani Gmel.¹—Boiss. 5 : 383.

AP: Qudrani (1932 EFZ). S: Marshes of Kabbara (1924 E). CS: Nebi Rubin (1926 EFZ).

Carex pachystylis J. Gay—Fl. U.R.S.S. 3 : 197.

EP: Balfouria (1922 E). J: Jerusalem (1931 Amdursky). PD: 17 km E of Jerusalem (1934 EFZ). NN: Tel Milh (1927 Smoly). UJ: Naharaim

¹ Determined by SAMUELSSON.

- (1933 EFZ). A: Amman (1929 *Naftolsky*). DA: Saheb (1927 EFZ). M: el Qutrani (1936 EFZ). E: Ma'an (1929 EZ).
- Carex Pairaei* F. Schulz¹—Fl. 51: 303 (1868).
UG: Betw. Tarshiha and Peki'in (1926 EZ).
- Carex pseudocyperus* L.—Boiss. 5: 428.
S: Env. of Hedera, Birketh Batih (1932 E).
- Aristida obtusa* Del. — Boiss. 5: 494.
NN: 10 km S of Beersheba (1928 EFZ); SE of Qurnub (1936 EFZ).
FN: Ras el Naqb (1936 EFZ); env. of el Kuntilla (1936 EFZ). E: el Hesma, N of Quweira (1936 EFZ).
- Aristida Raddiana* Savi.—Hernard Monogr. Arist. 1: 64 (1932).
FN: Wadi el Masri, 5 km of the outlet, on granit (1936 EFZ); 12 km. SE of Qurnub, *Calligonetum comosi* (1936 EFZ). LJ: Arnon river, Nubian sandstone (1936 EF); Callirrhoë (1925 E).
- Aristida hirtigluma* Steud.—Boiss. 5: 496.
FN: Wadi el Masri; 3 km. of the outlet (1936 EFZ).
- Stipa Szowitsiana* Trin.—Boiss. 5: 503.
JD: Betw. Hebron and Beni Naim (1934 EFZ); Bir Rothamieh (1934 EFZ). NN: Betw. 'Asluj and Hafir (1928 EFZ); N of Beersheba, ca. 500 m. (1934 EFZ). E: S of Jurf ed Derawish ca. 1000 m. (1936 EFZ).
This and the following *Stipa* species were confused with *S. barbata* Desf.
- Stipa Hohenackeriana* Trin. et Rupr.—Boiss. 5: 502.
DA: el Muakkar to el Kharani (1927 EFZ). E: el Hasa to Menzil (1929 EZ).
- Eleusine indica* (L.) Gaertn.—Boiss. 5: 555.
S: Pardes Hanna (1935 *Duvdevani*).
Probably adventitious.
- Eragrostis interrupta* (Lam.) P.B.²
CS: Wadi Misrara (1927 E).
- Briza spicata* S. et S.—Boiss. 5: 393.
G: Wadi Waran (1927 E).
- Vulpia pectinella* (Del.) Boiss.—Boiss. 5: 631.
NN: 'Asluj (1928 EFZ); 10 km. S of Beersheba (1928 EFZ).
- Agropyrum orientale* (L.) R. et S.—Boiss. 5: 668.
DA: El Muakkar to el Kharani (1927 EFZ). E: Jurf ed Derawish (1929 EZ); env. of Ma'an (1929 EZ).
- Marsilia diffusa* Leprieur—Boiss. 5: 750.
HP: N of Malahie (1935 R. T. Jones).

¹ Determined by SAMUELSSON.

² Determined by PILGER.

מיוחדים במדבר סוריה. שלושת החבלים האלה אינם שווים בהיקפם: החבל היס-תיכוני הוא הקטן ביותר והסהררסינדי הגדול ביותר. כן נתנים בעבודה הזאת טפסי הצומח האפיוניים ביותר לכל חבל וחבל.

הקבוצות הדור' והרב'אזוריות מכילות הרבה הלופיטים, הידרופיטים וצמחים אנטרופופיליים. אולם מלבד אלה מכילות הן (ביחוד הקבוצה המזרח'ים-תיכונית-אירנו-טורנית) גם הרבה צמחים של בתי גדול פרימריים שאינם קשורים לתנאים אידפיים מיוחדים.

מבין 171 המינים האנדמיים של הארץ הזאת נמנים 139 לאלמנט האירנו-טורני, 14 לאלמנט היס-תיכוני ו-18 לאלמנט הסהררסינדי.

II צמחים חדשים לארץ-ישראל

מאת א. איג ונ. פינברון

נתנת תוספת שניה של צמחים חדשים לארץ-ישראל הנמצאים בעשבת המחלקה לבוטניקה. ברשימה מפורטים 73 צמחים; רבם לא היה ידוע עד כה מא"י ימעוטם מסופקים או ידועים ממקורות בלתי מוסמכים. אחדים מהם לא הוכללו בפלורה של בואסיה. כן מתוארים כאן 6 וריאטטים חדשים למדע.

- ב. המקורים והקשוות של הפרות הנקובים מכילים חמרים מיוחדים, המעכבים את גביטת הזרעים.
- ג. בחרדל לבן נכרת יותר פעולת העכוב במקורים מאשר בקשוות.
- ד. חמרי העכוב שבחרדל הלבן מתמוססים במים ואינם רגישים כלפי חום.
- ה. פעילותם של חמרי העכוב נחלשת בד בבד עם מהולם.

הפעולה של דיפניל על הפיטריות DIPLODIA ו- PENICILLIUM

מאת א. פרקש וי. אמן

נחקרה השפעת אדי דיפניל על *Penicillium Penicillium digitatum itali-* על *Diplodia* ו- *cum*, על קרקעות מזון שונים. התפתחות פטריות אלה נפסקת ברכוז של 0.08 מ"ג בליטר אויר המתאים ללחץ האדים הרוויים של דיפניל ב"25. רכוז של 0.014 מ"ג דיפניל בליטר אויר מספיק כדי להקטין את מהירות הגדול עד כדי מחצית של ערכו הנורמלי. ע"י הצגת *Pen. digitatum* להשפעת אדי דיפניל במשך שבועות אחדים נתגלה גזע העומד בפני אדי דיפניל ומתפתח בנוכחותו. הסתכלויות מיקרוסקופיות הראו שאדי דיפניל יכולים להמית קורים צעירים בה בשעה שנבגים וקורים זקנים יותר יכולים להתפתח תיכף עם הרחקת הדיפניל.

נתוח גיאובוטני של מדבר סוריה

מאת מ. זהרי

בעבודה הזאת נתן בפעם הראשונה נתוח פיטוגיאוגרפי של אותו חלק ארץ המכונה בשם מדבר סוריה במובן הרחב. אחרי סקירה קצרה על האורוגרפיה, הגיאולוגיה, הקרקעות, האקלים ותולדות החקירה הפלוריסטית של מדבר סוריה, נתנת אנליזה של הפלורה לקבוצות הפיטוגיאוגרפיות שלה. מלבד חמשת האלמנטים הפיטוגיאוגרפיים, הינו: האלמנט היס-תיכוני, המונה כאן 520 מינים, האלמנט האירנו-טורני, המונה כאן 588 מינים, האלמנט הסהררסינדי, המונה 239 מינים, הסודנו-דקני, המונה 24 מינים והאלמנט האירוסירי-צפון אמריקאי, המונה 10 מינים, משתתפים בהרכב הפלורה גם קבוצות פיטוגיאוגרפיות דו"רוב-אזוריות (המונות יחד 659 מינים).

מתוך כל הקבוצות הפיטוגיאוגרפיות הנמנות בעבודה הזאת קובעים להם רק האלמנטים היס-תיכוני, האירנו-טורני והסהררסינדי חבלים פיטוגיאוגרפיים

ג. חמרי העכוב גורמים להקטנת אחוז הנביטה, לפגור במהירות הנביטה ולפיגור רב בצמיחת השרשים והקוליאופטילות, כמו כן לדיפורמציה של כל הנבט. הם מעכבים את הצמיחה הנוספת של הנבט בכל דרגות התפתחותו.

ד. פעילותם של חמרי העכוב היא פונקציה של הרכוז. כשהם מרוכזים מאד הם גורמים לבטול מחלט של הנביטה. בד בבד עם המהול הולכת פעילותם וקטנה עד שבמהול גדול מתבטלת פעולתם לחלוטין.

ה. חמרי העכוב גורמים להחלשה או לאבוד של כוח הנביטה. שהיה קלה של הזרעים בתוכם דיה כבר כדי להחליש בהרבה את כוח נביטתם.

ו. ביחס למיכניזם של פעולתם, הרי ידוע לנו רק שאין הם משפיעים על התפיחה, על תהליכי החמצון בנשימה ועל פעולת הדיאסטזה בפרוק העמילן.

ז. שנוי התנאים החיצוניים אינו משפיע באופן ניכר על פעולותיהם הפיזיולוגיות של חמרי העכוב.

ח. במהולים הגדולים של מיץ העגבניות מופיע זרוז של הנביטה, התופס את מקומו של העכוב במיץ המרוכז. זרוז זה מופיע גם במיץ לאחר דיאליזה ממושכת מאד. הזרוז נכר הן ביחס לאחוז הנביטה והן ביחס למהירות הנביטה והתפתחות הנבטים.

ט. נבדקה גם השפעת התכונות הפיזיות גרידא של המיץ, כגון ערכו האוסמוטי הגבוה וחמיצותו, על התהוותו של העכוב בנביטה. הוכח, שאין ליחס לגורמים אלה חשיבות ממדרגה ראשונה, אם כי הם מסייעים לחמרי העכוב ביצירת העכוב הגדול.

3. חמרי העכוב בפרי של הסירה הקוצנית

מאת י. ואהל

הוכח כי:

- א. הפרי של הסירה הקוצנית מכיל חמרים מיוחדים המעכבים את הנביטה.
- ב. חמרי עכוב אלה נספחים מהפרי ע"י אמצעי ספוח שונים כגון פחם-דם או אבקת טלקום.
- ג. החמרים המעכבים הם כנראה חמרים וולאטיליים.

4. על עכוב הנביטה של זרעי חרדל לבן וזרעים אחרים כשהם סגורים בתוך פרותיהם

מאת רחל שרואלוב

העבודה עוסקת בחמרי העכוב שבפרות היבשים של משפחת המצליבים.

הוכח:

- א. כי זרעי החרדל הלבן, המנתור הדוקרני ושלח הערבות מתעכבים בנביטתם כשהם סגורים בפרותיהם.

עתוץ לבוטניקה

סיון ת"ש

סדרת ירושלים

כרך ב' חוב' א'

על חמרי העכוב של הנביטה

1. מבוא

מאת מ. אבן-ארי

נתנת סקירה כללית על בעית חמרי העכוב של הנביטה הנמצאים בתוך הפרי או בתוך הזרע, ובה תולדות החקירה של השאלה הנדונה וסכום העובדות הידועות בשאלה זו על סמך נתונים ספרותיים. החשובים שבנתונים אלה הם: חמרי העכוב נמסים במים, אפשר למצותם באתר, הם נספחים ע"י הקרקע וע"י אמצעי ספוח שונים כגון פחם דם, לעתים הם וולטיליים, הם אינם ספציפיים. ביחס לרגישותם כלפי חום מחולקות עדין הדעות. הרכבם החימי לוטה עדין בערפל. תופעת העכוב מלווה לעתים בזרז. את חמרי העכוב מצאו בחלקי הפרי השונים ובזרע עצמו. יש כנראה להתיחס לחמרי העכוב בזרעים ובפרות כאל תופעה כללית. בסוף המאמר מצורפת גם רשימה מלאה של הספרות המטפלת בשאלת חמרי העכוב.

2. על החמרים המעכבים את הנביטה בפרי העגבניה

מאת א. קוניס

החקירה מגסה לברר את תכונותיהם ופעולתם הפיזיולוגית של חמרי העכוב וכן גם את המיכניזם של פעולתם. החקירה העלתה כדלקמן:

א. הוכחה ואשרה מציאותם של חמרי עכוב מיוחדים במיץ העגבניה.

ב. חמרי העכוב הם חמרים בלתי ספציפיים, וולטיליים, רגישים כלפי חום ופעולתם נחלשת כבר בטמפ. של 60° צלזיוס. הם קריסטלואידיים, אפשר לספחם ע"י פחם דם גם כשהם בתמיסה וגם כשהם במצב גזי.

עתון לבוטניקה

מופיע בשתי סדרות

א. סדרת ירושלים:

יוצאת לאור ע"י חבר העובדים של המחלקה לבוטניקה באוניברסיטה העברית ירושלים. בכל שנה מופיעות 4 חוברות וכל חוברת נושאת עליה את תאריך הופעתה. כל כרך שנתי מכיל מ"מ 300 עד 400 עמודים.

ב. סדרת רחבות:

יוצאת לאור ע"י ה. ר. אופנהימר וי. ריכרט של התחנה לחקר החקלאות, רחבות, א"י. בכל שנה מופיעות 2 חוברות וכל חוברת נושאת עליה את תאריך הופעתה. כל כרך שנתי מכיל מ"מ 200 עד 250 עמודים.

*

במכתבים הנוגעים לענייני המערכת של סדרת ירושלים יש לפנות לד. ו. זיצ'ק, ת. ד. 620, ירושלים — ולענייני המערכת של סדרת רחבות לעורכי "עתון לבוטניקה", ת. ד. 15, רחבות.

*

את דמי החתימה יש לשלם למפרע ע"י שק או המחאת דואר לפי הכתובת: ההנהלה של העתון לבוטניקה, ת. ד. 620, ירושלים. מחיר החתימה הוא:

1,250 לא"י לשנה, בעד שתי הסדרות

0.900 לא"י לשנה, בעד סדרת ירושלים בלבד

0.600 לא"י לשנה, בעד סדרת רחבות בלבד

בסכום זה נכללים גם דמי המשלוח.

(מחיר חוברת בודדת 0.300 לא"י ושל כפולה 0.600 לא"י)

*

במכתבים עסקיים, בכלל זה הודעה על שנוי כתובת, מודעות וכו' יש לפנות להנהלת העתון לבוטניקה, ת. ד. 620, ירושלים.

ע ת ו ז ל ב ו ט נ י ק ה

סדרת ירושלים

יוצא לאור על ידי

חבר העובדים של המחלקה לבוטניקה באוניברסיטה העברית

ת כ ן

עמוד

על חמרי העכוב של הנביטה

- I. מבוא. מאת מ. אבן-ארי א
- II. על החמרים המעכבים את הנביטה בפרי העגבנית. מאת א. קוניס א
- III. חמרי העכוב בפרי של הסירה הקוצנית. מאת י. ואהל ב
- IV. על עכוב הנביטה של זרעי חרדל לבן וזרעים אחרים כשהם סגורים בתוך פרותיהם. מאת רחל שרואלוב ב
- הפעלה של דיפניל על הפטריות Penicillium ו-Diplodia מאת א. פרקש וי. אמן ג
- נתוח גיאובוטני של מדבר סוריה. מאת מ. זהרי ג
- צמחים חדשים לארץ-ישראל II. מאת א. איג יונ. פינברון ד

ירושלים